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BLACK AND VEATCH KANSAS CITY MO

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NATIONAL DAM SAFETY PROGRAM. PERTLE SPRINGS LAKE DAM (MO 20044)--ETC(U)

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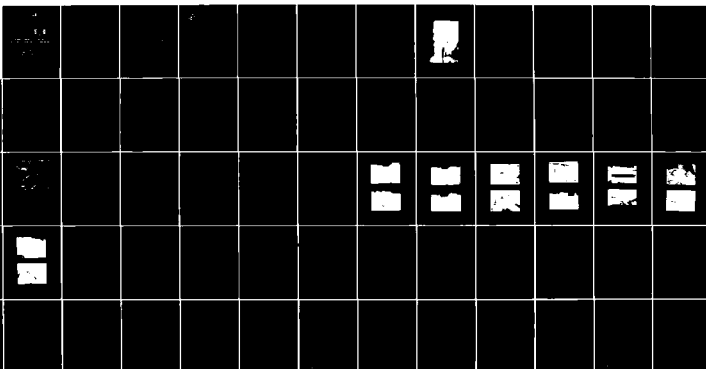
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MISSOURI-KANSAS CITY BASIN

PERTLE SPRINGS LAKE DAM

JOHNSON COUNTY, MISSOURI

MO 20044

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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM

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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

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19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams			
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.			

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PERTLE SPRINGS LAKE DAM

JOHNSON COUNTY, MISSOURI

MO 20044

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PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



United States Army
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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

FOR: STATE OF MISSOURI

MAY 1980



DEPARTMENT OF THE ARMY

ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

LMSD-PD

SUBJECT: Pertle Springs Lake Dam, MO. I.D. No. 20044
Phase I Inspection Report

This report presents the results of field inspection and evaluation
of the Pertle Springs Lake Dam.

It was prepared under the National Program of Inspection of Non-
Federal Dams.

This dam has been classified as unsafe, non-emergency by the St.
Louis District as a result of the application of the following
criteria:

- Spillway will not pass 50 percent of the Probable Maximum
Flood without overtopping the dam.
- Overtopping of the dam could result in failure of the dam.
- Dam failure significantly increases the hazard to loss of
life downstream.

SIGNED

SUBMITTED BY:

Chief, Engineering Division

25 SEP 1980

Date

SIGNED

APPROVED BY :

Colonel, CE, District Engineer

25 SEP 1980

Date

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PERTLE SPRINGS LAKE DAM
JOHNSON COUNTY, MISSOURI
MISSOURI INVENTORY NO. 20044

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:
BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF
ST. LOUIS DISTRICT CORPS OF ENGINEERS
FOR
GOVERNOR OF MISSOURI

MAY 1980

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Pertle Springs Lake Dam
State Located	Missouri
County Located	Johnson County
Stream	Tributary to East Fork Post Oak Creek
Date of Inspection	15 May 1980

Pertle Springs Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.


The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are one trailer court, one 1-acre lake, and one 20-acre lake. Contents of the estimated damage zone were verified by the inspection team.


The inspection and evaluation indicates that the spillways do not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillways will pass neither 50 nor 100 percent of the probable maximum flood without overtopping but will pass 25 percent of the probable maximum flood. The spillways will pass the flood which has a 1 percent chance of occurrence in any given year. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the volume of water impounded behind the dam, and the contents of the estimated damage zone, the spillway design flood should be 100 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

I Based on visual observations, this dam appears to be in satisfactory condition. Deficiencies visually observed by the inspection team were, seepage downstream of the dam on the right abutment, seepage from under the emergency spillway concrete inlet structure, erosion of embankment material on the upstream slope beneath the riprap, and numerous animal burrows on the embankment. Seepage and stability analyses required by the guidelines were not available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.


Paul R. Zaman, PE
Illinois 62-29261


Edwin R. Burton, PE
Missouri E-10137


Harry L. Callahan, Partner
Black & Veatch



OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
PERTLE SPRINGS LAKE DAM

TABLE OF CONTENTS

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 1 - PROJECT INFORMATION		
1.1	General	1
1.2	Description of Project	1
1.3	Pertinent Data	2
SECTION 2 - ENGINEERING DATA		
2.1	Design	6
2.2	Construction	6
2.3	Operation	6
2.4	Geology	6
2.5	Evaluation	6
SECTION 3 - VISUAL INSPECTION		
3.1	Findings	8
3.2	Evaluation	10
SECTION 4 - OPERATIONAL PROCEDURES		
4.1	Procedures	11
4.2	Maintenance of Dam	11
4.3	Maintenance of Operating Facilities	11
4.4	Description of Any Warning System in Effect	11
4.5	Evaluation	11
SECTION 5 - HYDRAULIC/HYDROLOGIC		
5.1	Evaluation of Features	12
SECTION 6 - STRUCTURAL STABILITY		
6.1	Evaluation of Structural Stability	14

TABLE OF CONTENTS (Cont'd)

<u>Paragraph No.</u>	<u>Title</u>	<u>Page No.</u>
SECTION 7 - ASSESSMENT/REMEDIAL MEASURES		
7.1	Dam Assessment	15
7.2	Remedial Measures	15

LIST OF PLATES

<u>Plate No.</u>	<u>Title</u>
1	Location Map
2	Vicinity Topography
3	Plan
4	Dam Cross Section
5	Plan at Emergency Spillway Area
6	Emergency Spillway Sections
7	Photo Index

LIST OF PHOTOGRAPHS

<u>Photo No.</u>	<u>Title</u>
1	Upstream Face of Dam Looking West
2	Upstream Face of Dam Looking East
3	Crest of Dam
4	Downstream Slope of Dam
5	Primary Spillway Drop Inlet
6	Primary Spillway Outlet

TABLE OF CONTENTS (Cont'd)

LIST OF PHOTOGRAPHS

<u>Photo No.</u>	<u>Title</u>
7	Channel Below Primary Spillway
8	Emergency Spillway
9	Emergency Spillway Concrete Sill Looking Upstream
10	Channel Below Emergency Spillway Sill
11	Seepage From Below Emergency Spillway Concrete Apron
12	Seepage Area Below Dam at Right End
13	Animal Burrow in Upstream Face of Dam
14	Animal Burrow in Downstream Slope of Dam Near Toe
15	Small Pond Above Pertle Springs Lake
16	Downstream Face of Dam for Upper Lake
17	Upstream Face of Dam for Upper Lake
18	Outlet Pipe From Upper Lake

APPENDIX

Appendix A - Hydrologic Computations

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Pertle Springs Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of a tributary to East Fork Post Oak Creek (Plate 1). The watershed is an area of low hills consisting of approximately 70 percent forested area, 5 percent residential area, 10 percent grassland and 15 percent crop land (Plate 2). The dam is approximately 560 feet long along the crest and 20 feet high. The dam crest is 10 feet wide. The downstream face of the dam slopes gradually from the crest to the valley floor below.

(2) The primary spillway from the lake is an uncontrolled 60-inch Drop Inlet constructed of steel pipe connected to a 36-inch horizontal steel outlet pipe installed in the embankment. Flow through the pipe discharges into a rock and concrete channel below. The emergency spillway consists of a rectangular concrete notch overflow structure with a concrete sill which discharges to a concrete apron, then to a channel excavated from the embankment material and natural overburden. Discharge through the emergency spillway overflows through the valley downstream to a small lake.

(3) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in central Johnson County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Centerview, Missouri in Section 35 of T46N, R26W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Pertle Springs Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Pertle Springs Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are one trailer court, one 1-acre lake and one 20-acre lake. Contents of the estimated damage zone were verified by the inspection team.

e. Ownership. The dam is owned by Central Missouri State College, Warrensburg, Missouri, 64093, Telephone 816-429-4111.

f. Purpose of Dam. The dam forms a 16-acre lake used for recreation which was originally used for water supply.

g. Design and Construction History. Data relating to the design and construction were not available.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, and overflow through the emergency spillway and uncontrolled outlet pipe all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 454 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled 60-inch drop inlet connected to a 36-inch outlet pipe.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation 700 cfs (Probable Maximum Flood Pool El. 779.1).

c. Elevation (Feet above m.s.l.).

- (1) Top of dam - 777.6 (see Plate 3)
- (2) Emergency spillway crest - 774.4
- (3) Primary spillway crest - 774.0
- (4) Streambed at toe of dam - 757.0 \pm
- (5) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 2,200 feet \pm (Probable maximum flood pool level)

(2) Length of normal pool - 1,800 feet \pm (Primary spillway crest)

e. Storage (Acre-feet).

- (1) Top of dam - 149
- (2) Emergency spillway crest - 82
- (3) Primary spillway crest - 75
- (4) Design surcharge - Not available.

f. Reservoir Surface (Acres).

- (1) Top of dam - 25.8
- (2) Emergency spillway crest - 17.2
- (3) Primary spillway crest - 16.1

g. Dam.

- (1) Type - Earth embankment
- (2) Length - 560 feet
- (3) Height - 20 feet ±
- (4) Top width - 10 feet
- (5) Side slopes - upstream face 1.0 V on 2.6 H, downstream face between 1.0 V on 2.8 H and 1.0 V on 5.0 H (see Plate 4)
- (6) Zoning - Unknown.
- (7) Impervious core - Unknown.
- (8) Cutoff - Unknown.
- (9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Primary Spillway.

- (1) Type - 60-inch drop inlet steel pipe connected to 36-inch steel outlet pipe.
- (2) Inlet crest - 774.0 feet m.s.l.
- (3) Outlet invert elevation 754.7 feet m.s.l.
- (4) Gates - None.
- (5) Upstream channel - Not applicable.
- (6) Downstream channel - Rock and concrete channel

j. Emergency Spillway.

- (1) Type - Rectangular concrete notch.
- (2) Width of channel - 16 feet.

- (3) Emergency spillway crest - 774.4.
 - (4) Gates - None.
 - (5) Upstream channel - Not applicable.
 - (6) Downstream channel - Concrete apron then into a downstream soil and rock channel.
- k. Regulating Outlets - None. Drain valve located in primary spillway drop inlet pipe. Size and elevation unknown.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data was unavailable.

2.2 CONSTRUCTION

Construction records were unavailable.

2.3 OPERATION

Procedural criteria for operation of this dam were not available. Documentation of past experiences of a serious nature was also not available.

2.4 GEOLOGY

The site of the dam and reservoir is located in a deeply dissected valley between two ridges. The dam impounds a small intermittent tributary of the East Fork of Post Oak Creek.

The soils of the dam and reservoir area consist of the Bolivar and Blackoar soil series. The Bolivar series consists of moderately deep, well-drained soils formed in residuum from sandstone on uplands. The depth to rock is 20-40 inches. For engineering purposes the soils are classified as low plastic silt (ML), silty sand (SM), clayey sand (SC) or low plastic clays (CL). The Blackoar series consists of deep, poorly-drained soils on nearly level areas in the floodplain. The depth to bedrock is greater than 60 inches. For engineering purposes the soil is classified as a low-plastic silt (ML) or a low plastic clay (CL).

The bedrock of the dam and reservoir area consists of sandstone of the Warrensburg member of the Pleasanton Group, Desmoinesian Series, Pennsylvanian System. The sandstone is a channel sandstone that is massive, medium grained, micaceous, and crossbedded.

2.5 EVALUATION

a. Availability. No engineering data could be obtained.

b. Adequacy. No engineering data was available upon which to make a detailed assessment of the design, construction, and operation. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability

analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Pertle Springs Lake Dam was made on 15 May 1980. The inspection team consisted of Edwin R. Burton, team leader; Robert Pinker, geologist; Gary Van Riessen, geotechnical engineer; John Ruhl, hydrologist/hydraulic engineer; and Russell Burnham, structural engineer. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. No cracks, sloughing or other signs of settlement were observed. No instruments to measure the performance of the dam were located.

Seepage was observed on the right abutment and downstream of the embankment but no visible flow was evident. Clear seepage (about 5 gpm) was observed coming from under the emergency spillway concrete inlet structure. No toe drains or relief wells were observed.

The dam crest has a gravel roadway surface which has been subjected to heavy foot traffic. The upstream slope of the embankment is faced with riprap. The downstream slope has a clover-type vegetative cover. Some erosion was evident on the upstream slope as indicated by occasional holes and pockets in the riprap. Also, erosion of the sandy silt/sandy clay embankment material at the emergency spillway to near the crest of the dam may indicate that the dam has been overtopped. Backfill concrete had been placed around the emergency spillway structure to repair the embankment.

Evidence that a maintenance program was in effect included mowing of grass on the embankment, cutting of trees noted by a few stumps on the embankment and the clover-type vegetative cover planted on the downstream slope which appeared to be fairly new. It was perhaps the first or second year since planting as evidenced by the presence of straw mulch.

Many animal burrows were observed on the embankment. The area considered as the upstream channel to the lake contains several small dams and lakes located in an area of low hills. The lake water was noted to be clear containing a minor amount of siltation.

c. Appurtenant Structures. The inspection team observed the following items pertaining to the appurtenant structures. The primary spillway consists of an uncontrolled 60-inch drop inlet constructed of steel pipe connected to a 36-inch horizontal steel outlet pipe. The inlet has wire trash screens and a steel hatch cover. A valve stem was observed inside the drop inlet but could not be investigated further since the hatch cover was locked. The 36-inch outlet pipe was inspected from the downstream end and was found to be straight. About 4-feet of the drop inlet pipe interior was inspected and no corrosion was found. No evidence of leakage was noted into, out of or around the spillway pipe. The pipe joints themselves could not be observed and the majority of the spillway pipe was considered unobservable.

Some backfill concrete was recently placed on the upstream face of the dam around the drop inlet, probably to replace eroded embankment material. The primary spillway is considered to be in satisfactory condition.

The emergency spillway consists of a rectangular concrete notch inlet structure with a concrete control sill which discharges onto a backfill concrete apron then into a downstream soil and rock channel. This concrete was inspected and found to be in satisfactory condition. As previously noted there was clear seepage (5 gpm) coming from under the emergency spillway backfill concrete apron. Also some unmeasurable seepage was observed coming from under the concrete sill. It was noted that the control sill concrete had been repaired.

The emergency spillway contains no obstructions to flow and is considered to be in satisfactory condition. Backfill concrete has been placed around the emergency spillway which may indicate that erosion of the sandy silt/sandy clay embankment material may have occurred and that the dam has been overtopped. It should be noted that an abnormally large spillway discharge would probably overflow and erode the embankment.

There was no development in the emergency spillway area which could suffer damage due to flow through the spillway.

d. Geology. The soils in the area of the dam and reservoir are formed in alluvium and in residuum from sandstone. The alluvial soils are present in the downstream channel and consist of silts and sandy clays of low plasticity (ML or CL). The soils on the slopes around the reservoir are silty or clayey sands (SM or SC).

No outcrops of rocks were observed in the area of the dam and reservoir. However, the general depth to rock is anticipated to be 2-5 feet on the slopes and 10-20 feet in the downstream channel.

Samples of the embankment were taken near the center of the upstream crest using an Oakfield sampler. The materials were classified as one foot of sandy silt (ML) over sandy clay (CL) in accordance with ASTM D 2488-69. Based on these samples, it is anticipated that the embankment consists of sandy clay with a cover of approximately one foot of sandy silt.

The abutments and foundation of the dam are anticipated to consist of silty clay or silty sand overlying sandstone bedrock.

e. Reservoir Area. No slumping or slides of the reservoir banks were observed.

f. Downstream Channel. No obstructions, slumping, or slides were observed in the downstream channel.

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control. The three seepage areas that were observed, on the right abutment, below the dam and under the emergency spillway concrete inlet structure, should be monitored regularly for quality and quantity. Seepage can lead to piping failure of the embankment and/or abutment material.

Burrowing animals will continue to damage the embankment if no program is undertaken to eliminate them. Piping failure of the embankment has resulted in similar small earth dams due to burrowing animal damage.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, and capacity of the emergency spillway and the uncontrolled primary spillway outlet pipe.

4.2 MAINTENANCE OF DAM

The existing maintenance program includes removal of brush and mowing the grass on the crest and slopes of the dam. Some recent concrete repair work was noted at the primary and emergency spillways.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

The maintenance program should continue to include mowing the grass cover on the embankment in order to discourage animal burrowing. A program should be undertaken to eliminate the burrowing animals. The areas of seepage should be monitored periodically and, if flows increase significantly or if seepage flows become muddy, a professional engineer experienced in the design, construction, and inspection of earth dams should be consulted.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data were unavailable.

b. Experience Data. The drainage area and lake surface area are developed from USGS Centerview Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The primary spillway appears to be in good condition. The lake level at the time of the inspection was below the inlet level and there was no flow through the pipe. Only the inlet and outlet ends were observable. The spillway pipe discharges to a channel constructed of rock and concrete. There were no obstructions to flow in the downstream channel.

(2) The emergency spillway channel is in good condition with no evidence of erosion at the time of the inspection. Seepage flow of approximately 5 gpm was observed flowing from beneath the discharge apron.

(3) Spillway discharges do not endanger the integrity of the dam.

d. Overtopping Potential. The hydrologic and hydraulic analyses for the subject reservoir including routing through the upstream reservoir are outlined in Appendix A. The spillways will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillways will pass 25 percent of the probable maximum flood without overtopping the dam. The spillways will pass the one percent chance flood estimated to have a peak outflow of 530 cfs developed by a 48-hour, one percent chance rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the volume of water impounded by the dam, and the contents of the estimated damage zone, the appropriate spillway design flood should be 100 percent of the probable maximum flood. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 1,400 cfs of the total discharge from the reservoir of 2,000 cfs. The estimated duration of overtopping is

2.0 hours with a maximum height of 0.7 feet. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 3,500 cfs of the total discharge from the reservoir of 4,200 cfs. The estimated duration of overtopping is 5.3 hours with a maximum height of 1.5 feet. The embankment could be in jeopardy should it be overtopped for this period of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. One trailer court, one 1-acre lake, and one 20-acre lake could be severely damaged and lives could be lost should failure of the dam occur. Contents of the estimated damage zone were verified by the inspection team. There does not appear to be any floodplain regulations or other constraints in force to limit future downstream development.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records were available.

d. Postconstruction Changes. It appears that additional concrete work has been performed on the emergency spillway discharge apron since the spillway's original construction. The date and reason for the work are unknown.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry.

Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are seepage from the right abutment, below the dam and under the emergency spillway concrete inlet structure, erosion of embankment material on the upstream slope beneath the riprap, and animal burrows in the embankment. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional investigation noted in paragraph 2.5.b is necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment was not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The emergency spillway size and/or height of the dam would need to be increased or the lake level would need to be lowered to increase storage in order to pass the spillway design flood. Any

work undertaken to remedy the hydraulic inadequacies should consider effects on the Lions Lake reservoir downstream of the subject embankment.

b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be carried out under the direction of an engineer experienced in the design, construction, and inspection of earth dams:

(1) The eroded areas beneath the riprap on the upstream face should be excavated, backfilled, and compacted with suitable material and the riprap should be repaired.

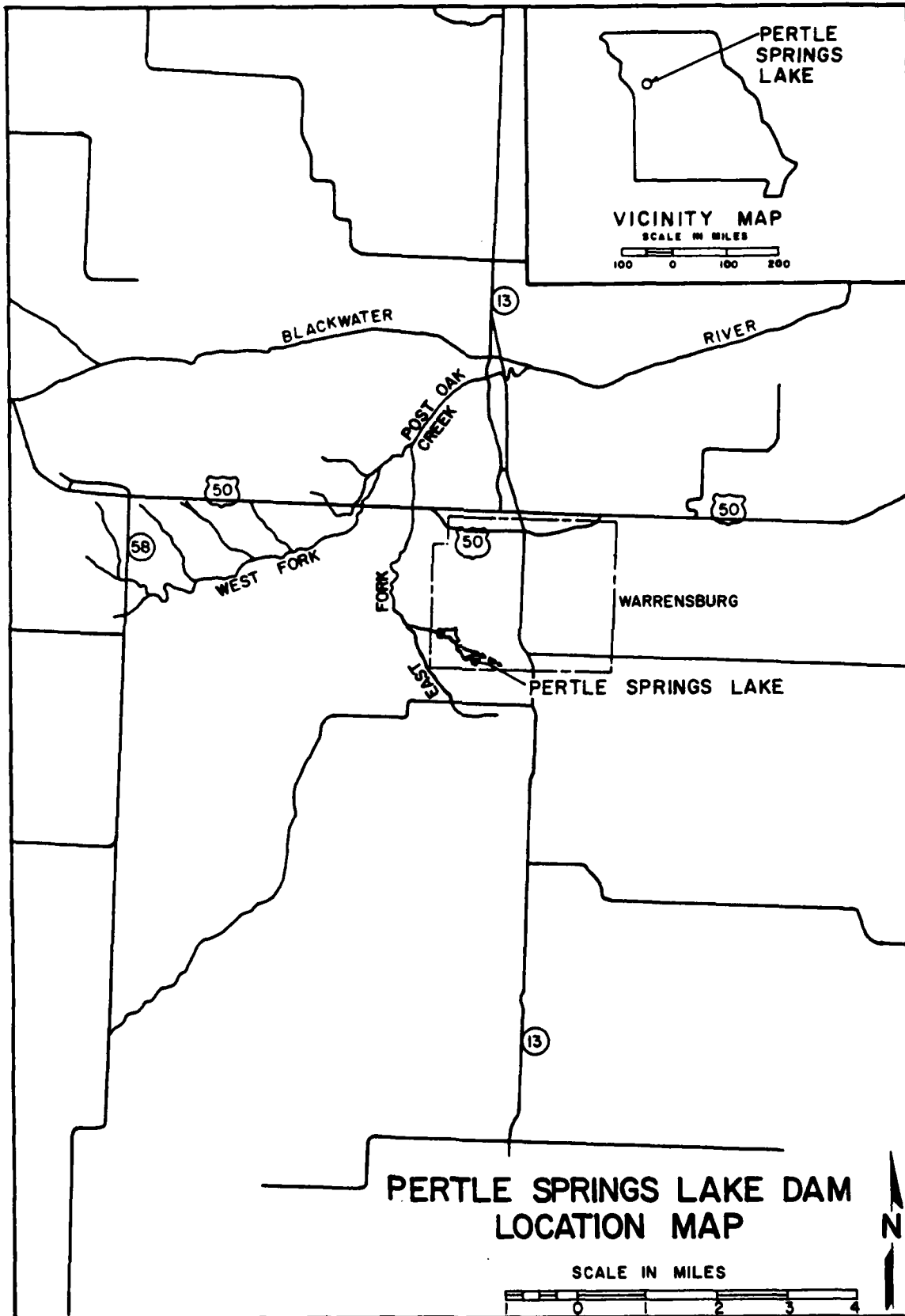
(2) The seepage areas noted during the visual inspection should be closely monitored and documented as to quantity of flow. Any significant changes should be evaluated.

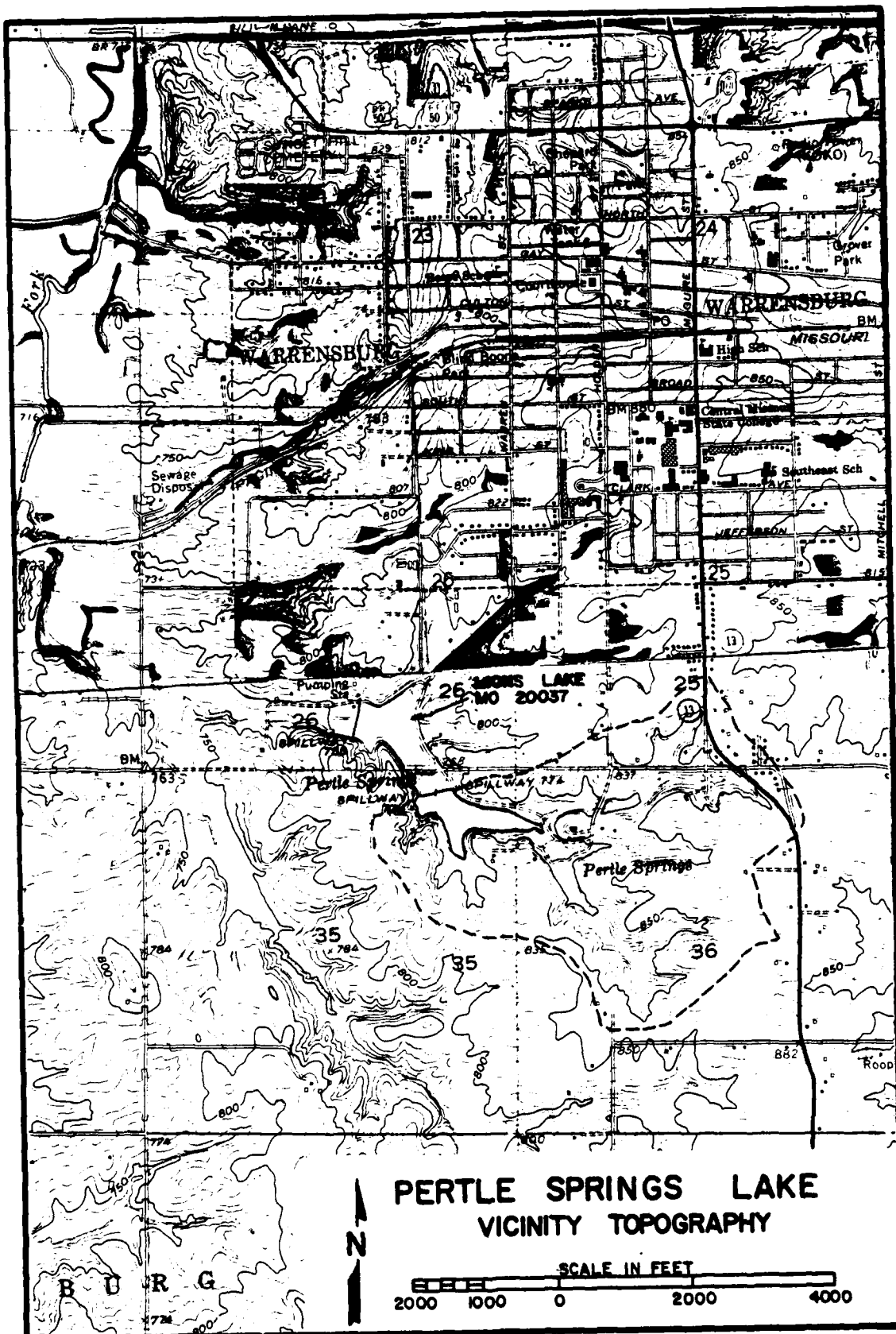
(3) The animal burrows in the embankment should be repaired since they can lead to piping. Control measures should be implemented to discourage animal activity in the area.

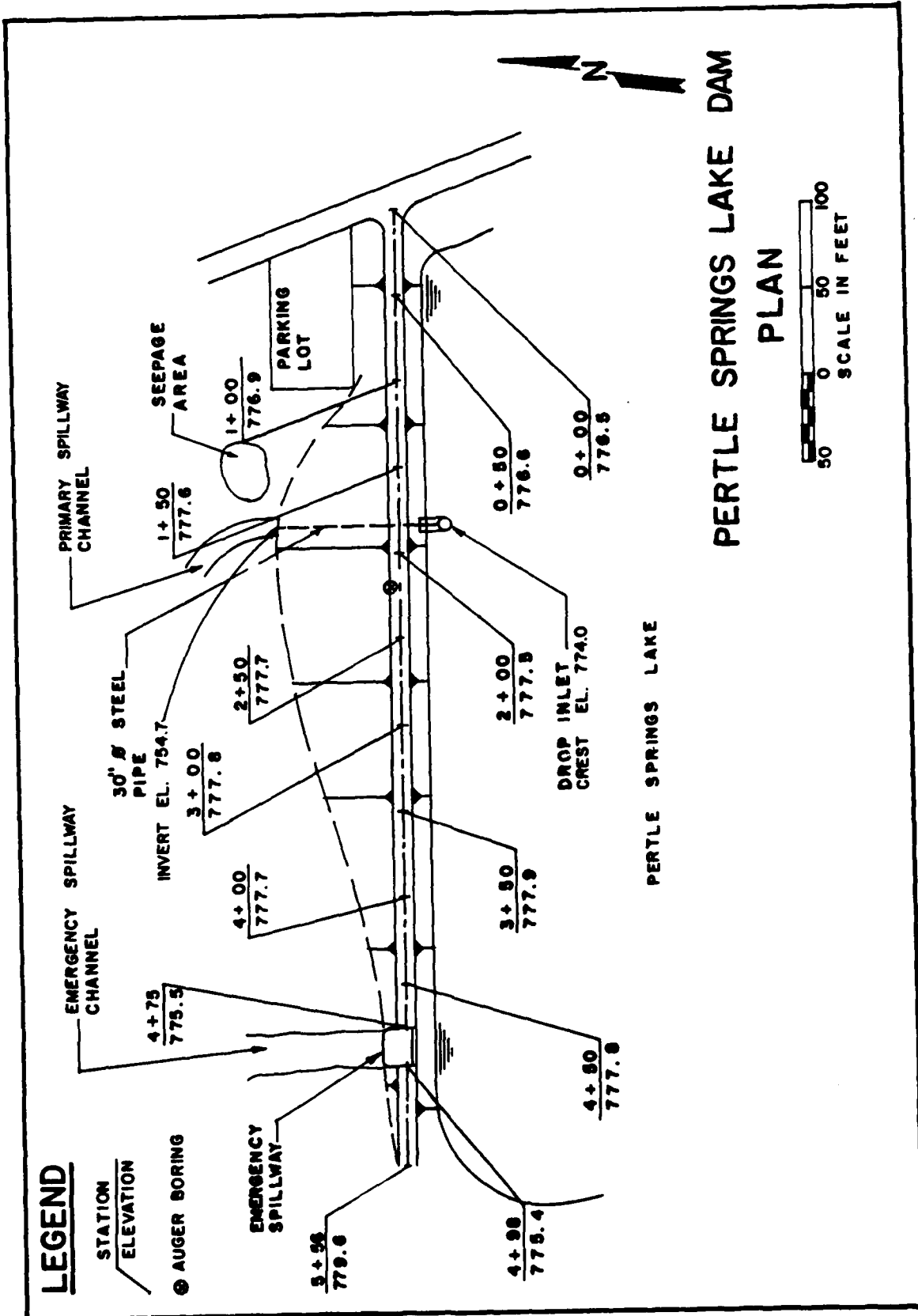
(4) An improved maintenance program to remove and control the growth of brush and trees on the embankment should be developed. Grass cover on the embankments should be cut periodically.

(5) Seepage and stability analyses should be performed.

(6) A detailed inspection of the dam should be made periodically. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.

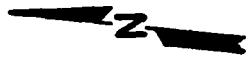




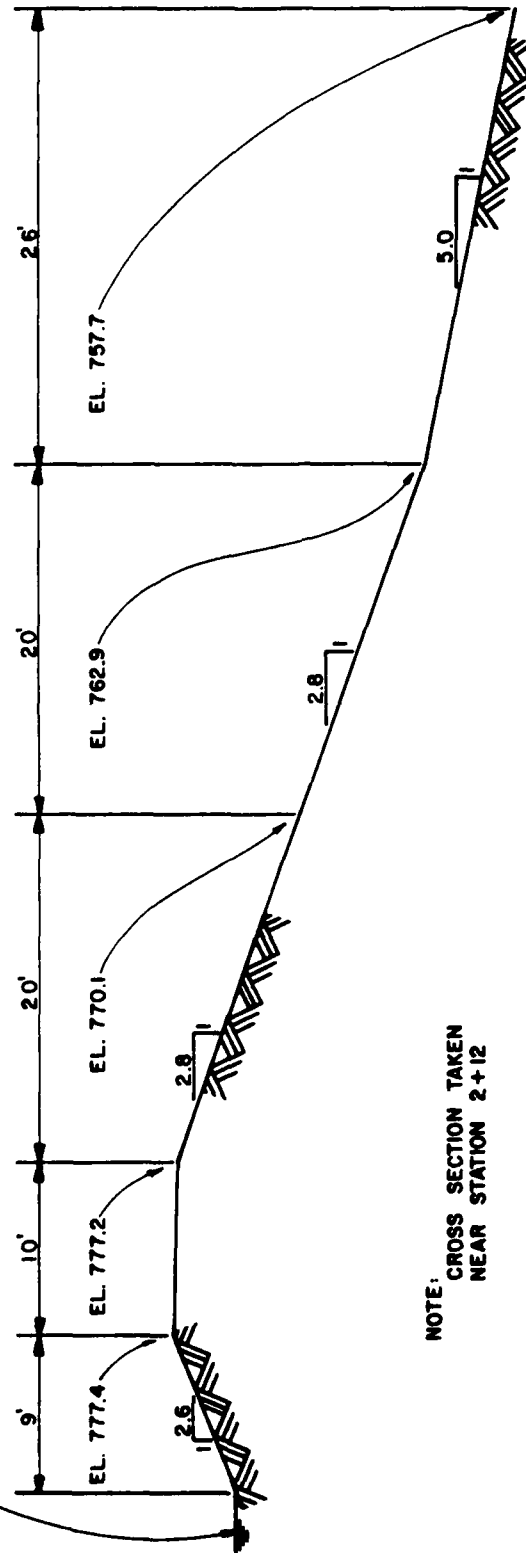


PERTLE SPRINGS LAKE DAM

PLAN



PERTLE SPRINGS LAKE LEVEL
AT TIME OF INSPECTION 773.9



NOTE: CROSS SECTION TAKEN
NEAR STATION 2+12

PERTLE SPRINGS LAKE DAM DAM CROSS SECTION

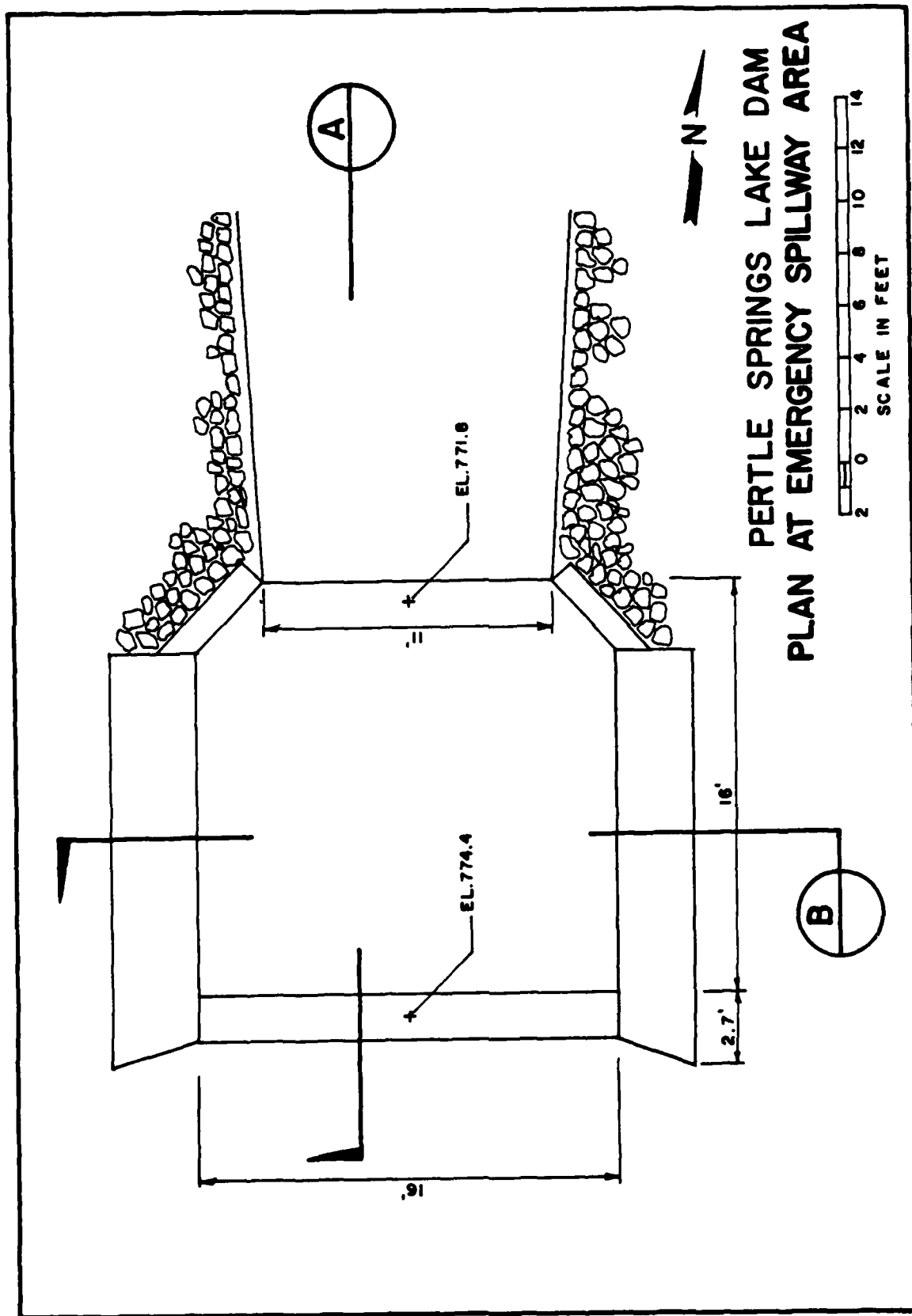
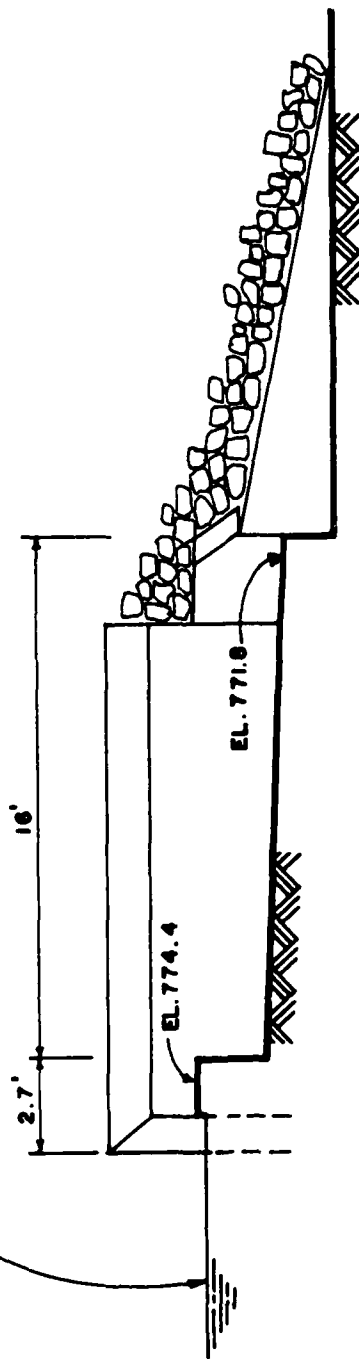
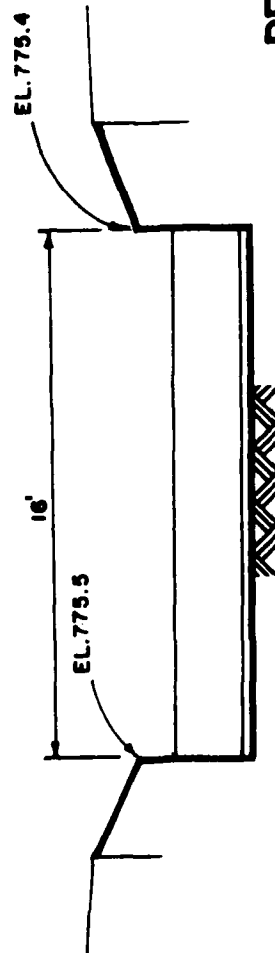


PLATE 5

PERTLE SPRINGS LAKE LEVEL
AT TIME OF INSPECTION EL. 773.9



SECTION A



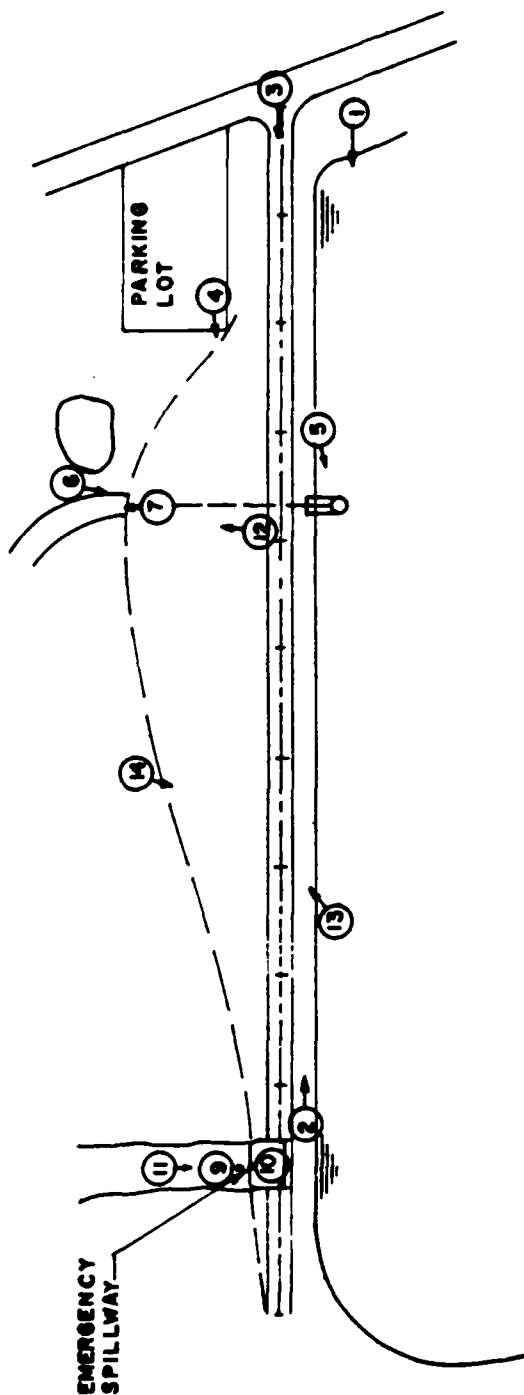
SECTION B

PERTLE SPRINGS LAKE DAM EMERGENCY SPILLWAY SECTIONS



LEGEND

① PHOTO NO. &
DIRECTION



PERTLE SPRINGS LAKE

NOTE: PHOTOS 15, 16, 17 & 18 ARE
LOCATED UPSTREAM OF
PERTLE SPRINGS LAKE

PERTLE SPRINGS LAKE DAM PHOTO INDEX

50 0 50 100
SCALE IN FEET



PHOTO 1: UPSTREAM FACE OF DAM LOOKING WEST



PHOTO 2: UPSTREAM FACE OF DAM LOOKING EAST



PHOTO 3: CREST OF DAM



PHOTO 4: DOWNSTREAM SLOPE OF DAM



PHOTO 5: PRIMARY SPILLWAY DROP INLET



PHOTO 6: PRIMARY SPILLWAY OUTLET



PHOTO 7: CHANNEL BELOW PRIMARY SPILLWAY



PHOTO 8: EMERGENCY SPILLWAY



PHOTO 9: EMERGENCY SPILLWAY CONCRETE SILL LOOKING UPSTREAM



PHOTO 10: CHANNEL BELOW EMERGENCY SPILLWAY SILL



PHOTO 11: SEEPAGE FROM BELOW EMERGENCY SPILLWAY CONCRETE APRON



PHOTO 12: SEEPAGE AREA BELOW DAM AT RIGHT END



PHOTO 13: ANIMAL BURROW IN UPSTREAM FACE OF DAM

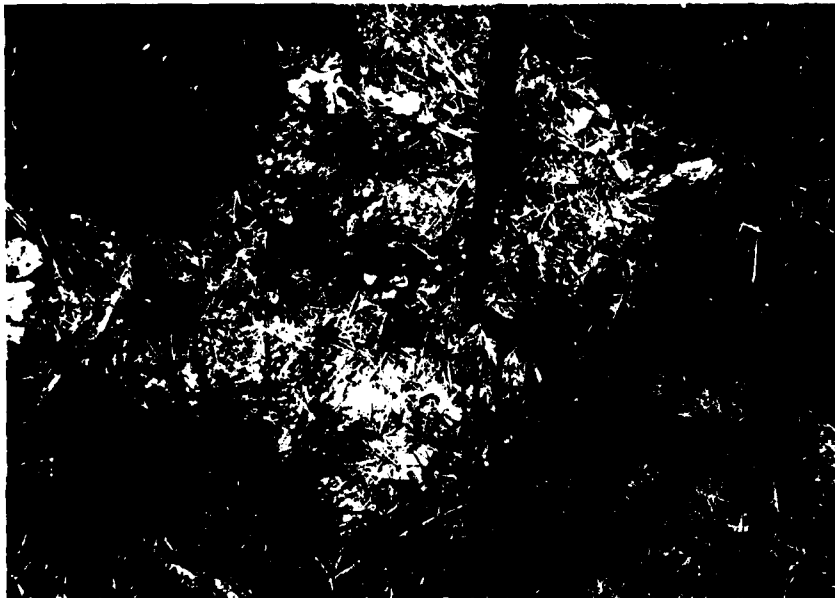


PHOTO 14: ANIMAL BURROW IN DOWNSTREAM SLOPE OF DAM NEAR TOE



PHOTO 15: SMALL POND ABOVE PERTLE SPRINGS LAKE

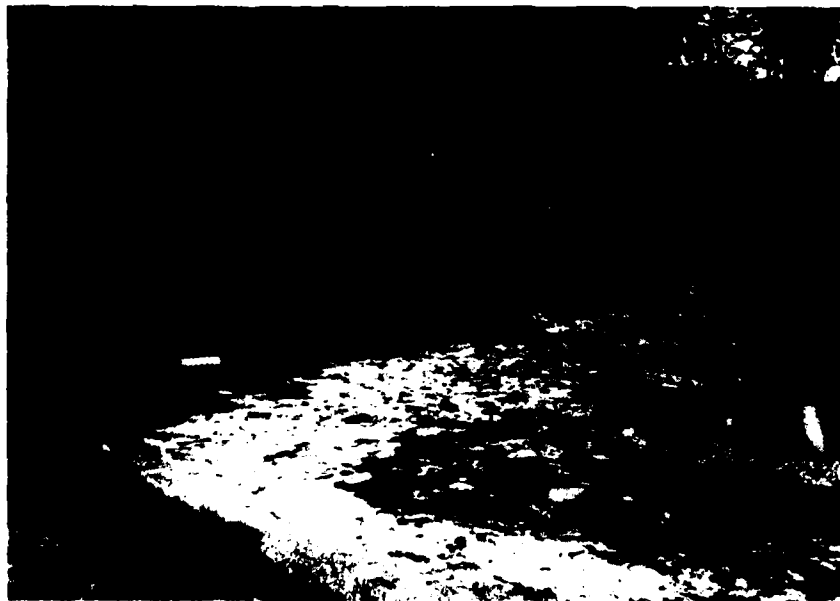


PHOTO 16: DOWNSTREAM FACE OF DAM FOR UPPER LAKE



PHOTO 17: UPSTREAM FACE OF DAM FOR UPPER LAKE



PHOTO 18: OUTLET PIPE FROM UPPER LAKE

APPENDIX A
HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential of Pertle Springs Lake Dam, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to synthetic unit hydrographs to develop inflow hydrographs for Pertle Springs Lake and its upstream reservoir. The inflow hydrographs were then routed through the reservoirs and spillways. The overtopping analyses were determined using the computer program HEC-1 (Dam Safety Version) (1).

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33" (HMR-33). Reduction factors were not applied. The rainfall distribution for the 48-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411. The Sweet Springs, Missouri rainfall distribution (10 min. interval - 48 hours duration), as provided by the St. Louis District, Corp of Engineers, was used when the one percent chance probability flood was routed through the reservoirs and spillways.

The synthetic unit hydrographs for the watershed were developed by the computer program using the Soil Conservation Service (SCS) method. The parameters for the unit hydrographs are shown in Table 1.

The SCS curve number (CN) method was used in computing the infiltration losses for rainfall-runoff relationships. The CN values used, and the result from the computer output, are shown in Table 2.

Although many impoundments exist in the watershed for Pertle Springs Lake, it was determined from visual inspection that only one of the impoundments upstream of Pertle Springs Lake would be included in the hydrologic and hydraulic analyses. Storms were routed through the lake upstream of Pertle Springs Lake (see Plate 2) which shall be referenced as "Upstream Lake" through the remainder of this appendix.

Routing through the reservoirs was performed using the Modified Puls Method. The initial reservoir pool elevations for the routing of each storm were determined to be equivalent to the primary spillway crest elevations in accordance with antecedent storm conditions preceding the one percent probability and probable maximum storms outlined by the U.S. Army Corps of Engineers, St. Louis District (5). The hydraulic capacity of the spillways and the storage capacity of the reservoirs were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curves for the spillways are shown in Table 4. The flow over the crest Pertle Springs Lake dam was determined using the non-level dam crest option (\$L and \$V cards) of the HEC-1 program. The flow over the upstream dam was determined by HEC-1 assuming a level dam crest.

The program assumes critical flow over a broad-crested weir. The flow through the upstream lake primary spillway was determined by a nomograph for corrugated metal pipe culverts with outlet control. The flow through the Pertle Springs primary spillway was determined from the orifice flow equation. The flow over the Pertle Springs Lake emergency spillway was determined from the weir equation.

Where routings through the upstream reservoir resulted in overtopping of that structure, a breach analysis was performed using HEC-1. The breaching parameters are noted in Table 5.

The result of the routing and breach analysis indicates that 25 percent of the PMF will not overtop the Pertle Springs Lake dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table 6.

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1
SYNTHETIC UNIT HYDROGRAPH

<u>Parameters:</u>	<u>Upstream Lake</u>	<u>Pertle Springs Lake</u>
Drainage Area (A)	179 acres	275 acres
Hydraulic Length of Watercourse (L)	3,900 feet	4,460 feet
Hydrologic Soil Cover	81 (AMC III)	80
Complex Number (CN')	64 (AMC II)	63
Average Watershed Land Slope (Y)	2.7%	2.6%
Lag Time (L _g)	0.56 hours (AMC III) 0.90 hours (AMC II)	0.65 hours 0.96 hours
Time of concentration (T _c)	0.93 hours (AMC III) 1.50 hours (AMC II)	1.08 hours 1.73 hours
Duration (D)	7 minutes (AMC III) 12 minutes (AMC II) (use 10 minutes in all cases)	9 minutes 14 minutes

TABLE 1
(Continued)

Time (Min)*	Upstream Lake		Discharge (cfs)* Pertle Springs Lake	
	AMC II	AMC III	AMC II	AMC III
0	0	0	0	0
10	11	32	12	35
20	33	106	35	112
30	67	190	71	224
40	108	210	120	280
50	132	182	160	274
60	137	129	182	229
70	129	80	184	162
80	112	53	173	107
90	89	35	154	75
100	64	23	129	52
110	48	15	98	36
120	37	10	75	25
130	28	6	58	17
140	21	4	47	12
150	16	3	37	8
160	12	2	29	6
170	9	1	23	4
180	7	1	18	3

*From HEC-1 computer output

FORMULAS USED:

$$L_g = \frac{2^{0.8} \times (S + 1)^{0.7}}{1,900 \times Y^{0.5}} \quad (4)$$

$$S = \frac{1,000}{CN'} - 10$$

$$T_c = L_g / 0.6$$

$$D = 0.133 T_c$$

TABLE 2
RAINFALL-RUNOFF VALUES

<u>Selected Storm Event</u>	<u>Storm Duration (Hours)</u>	<u>Rainfall (Inches)</u>	<u>Runoff (Inches)</u>	<u>Loss (Inches)</u>
PMP				
Upstream Lake	48	34.58	31.92	2.66
Pertle Springs Lake	48	34.58	31.75	2.83
1% Probability				
Upstream Lake	48	8.73	4.37	4.36
Pertle Springs Lake	48	8.73	4.25	4.48

Additional Data:

- 1) The soil associations in this watershed are Bolivar, Barco, Deepwater, Macksburg, Sampsel, and Weller (3).
97 percent of total drainage area in hydrologic soil group B.
3 percent of total drainage area in hydrologic soil group D.
5 percent of the land use was urban.
10 percent of the land use was grassland.
15 percent of the land use was cropland.
70 percent of the land use was timberland (2 and 4).
- 2) SCS Runoff Curve CN (AMC III) for ratios of the PMF:
81 - Upstream Lake
80 - Pertle Springs Lake
- 3) SCS Runoff Curve CN (AMC II) for the one percent probability flood:
64 - Upstream Lake
63 - Pertle Springs Lake

TABLE 3

ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

<u>Elevation (feet-MSL)</u>	<u>Lake Surface Area (acres)</u>	<u>Lake Storage (acre-ft)</u>	<u>Spillway Discharge (cfs)</u>
Upstream Lake			
*785.0	1.0	2	0
***789.2	2.7	9	11
Pertle Springs Lake			
*774.0	16.1	75	0
**774.4	17.2	82	14
***777.6	25.8	149	458

*Primary spillway crest elevation

**Emergency spillway crest elevation

***Top of dam elevation

The relationships in Table 3 were developed from the Centerview, Missouri and Cornelia, Missouri 7.5 minute quadrangle maps and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

<u>Reservoir Elevation (ft-msl)</u>	<u>Primary Spillway Discharge (cfs)</u>	<u>Emergency Spillway Discharge (cfs)</u>	<u>Total Spillway Discharges (cfs)</u>
Upstream Lake			
785.0	0	-	0
786.0	10	-	10
787.0	10	-	10
788.0	10	-	10
789.0	11	-	11
**789.2	11	-	11
790.0	11	-	11
791.0	12	-	12
Pertle Springs Lake			
774.0	0	-	0
*774.4	14	0	14
775.0	34	19	53
776.0	97	94	191
777.0	142	206	348
**777.6	158	300	458
778.0	169	363	532
779.0	191	524	715

*Emergency Spillway Crest Elevation

**Top of Dam Elevation

METHOD USED:

Upstream Lake

Primary spillway releases were determined by nomographs for corrugated metal pipe culverts with outlet control (7).

Pertle Springs Lake

Primary spillway release rates were based on the discharge calculated for flow through the pipe and drop inlet using the orifice equation:

$$Q = Ca[2gH]^{1/2}$$

where:

C = 0.77 = coefficient of discharge for pipe or

C = 0.57 = coefficient of discharge for drop inlet

a = 7.07 sq. ft. = net area of orifice for pipe or

a = 19.6 sq. ft. = net area of orifice for drop inlet

g = 32.2 ft/sec² = gravitational acceleration

H = difference between the energy gradient elevation upstream and the downstream tailwater elevation for pipe or

H = height of water surface above the crest of the drop inlet (6).

Emergency spillway release rates were computed using the weir equation:

$$Q = CLH^{3/2}$$

L = 16 feet

H = head in feet

C = coefficient of discharge and varies between 2.61 and 3.32 (6).

TABLE 5

BREACHING PARAMETERS

	<u>Upstream Lake</u>
Bottom Width of Breach (BRWID)	10 feet
Side Slope of Breach (z) (In feet horizontal to 1.0 feet vertical)	0.5
Elevation of Breach Bottom at Maximum Size of Breach (ELBM)	782.0 ft. m.s.l.
Time for Breach to Develop to Maximum Size (TFAIL)	1.0 hour
Elevation of Water Surface Which Will Cause Dam to Fail (FAILEL)	789.2 ft. m.s.l.

TABLE 6

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (CFS)	Peak Lake Elevation (ft.-MSL)	Total Storage (AC.-FT.)	Peak Outflow (CFS)	Depth (ft.) Over Top of Dam
-	0	*774.0	75	0	-
0.25	1,046	777.6	148	882	0
0.50	2,106	778.3	166	1,994	0.7
1.00	4,325	779.1	189	4,209	1.5

* Primary spillway drop inlet crest elevation.

BIBLIOGRAPHY

- (1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.
- (2) U.S. Department of Agriculture, Soil Conservation Service, Technical Release No. 55, Urban Hydrology for Small Watersheds, January, 1975.
- (3) U.S. Department of Agriculture, Soil Conservation Service, Preliminary Soils Report for Johnson County, Missouri.
- (4) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.
- (5) U.S. Army Corps of Engineers, St. Louis District, Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 12 December 1979.
- (6) Horace W. King and Ernest F. Brater, Handbook of Hydraulics, Sixth Edition, McGraw Hill Book Company, 1976.
- (7) U.S. Department of Commerce, Bureau of Public Roads, Hydraulic Engineering Circular No. 5, Hydraulic Charts for the Selection of Highway Culverts, December, 1965.
- (8) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.
- (9) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1976
LAST MODIFICATION 24 FEB 80

MISSOURI DAM INSPECTION PROGRAM
ST LOUIS DISTRICT US ARMY CORPS OF ENGINEERS
LIONS,PERTLE SPRINGS LAKE DAMS

JOB SPECIFICATION
NO NHR NMIN IDAY IMR IMIN METRC IPLT IPRT INSTAN
288 3 15 3 0 0 0 0 0
JOPEL NNT L2OPT TRACE
5 5 0 0 0

MULTI-PLAN ANALYSES TO BE PERFORMED
PLAN= 1 RTIO= 4 LRTIO= 1
RTIOS= .25 .30 .50 1.00

SUB-AREA RUNOFF COMPUTATION
UPSTREAM DAM (40 HR. PROBABLE MAXIMUM RUNOFF)

ISTAQ ICOMP IECON IFAPE JPLT JPRT INAME ISTAGE IAUTO
1 0 0 0 0 3 1 0 0

HYDROGRAPH DATA

INTDU TUNG TAREA SNAP TRSDA TRSPE RATIO JSNDW ISAWC LOCAL
1 4 .25 .00 .20 1.00 .000 0 0 0

PRECIP DATA

SPFE PMS R6 RT2 R48 R72 R96
.00 24.70 101.00 120.00 130.00 140.00 .00 .00

LOSS DATA

LROPT STRGR OLTRP RTIOL EASIN STRKS STPTL CNSTL ALSHX RTIMP
0 .00 .00 1.00 .00 .00 1.00 -81.00 .00
CURVE NO = -81.00 WEIKNSS = -1.00 EFFECT CN = 81.00

UNIT HYDROGRAPH DATA

TC= .50 LAG= .50

RECESSION DATA

STRIG= .00 GRCSN= .00 RTICR= 1.00

UNIT HYDROGRAPH 19 END OF PERIOD ORIGINATES. TCF .00 HOURS LAG= .55 VOL= 1.00
32. 106. 190. 210. 129. 82. 53. 35. 23.
15. TC. 6. 3. 2. 1. 1. 0.

END-OF-PERIOD FLO=

PC	HR-MN	PERIOD	RAIN	EQCS	LOSS	COMP	0-DA	HR-MN	PERIOD	RAIN	EQCS	LOSS	COMP
1-01	1-10	1	.00	.00	.00	0	1-02	1-10	145	.03	.02	.01	3
1-01	1-20	2	.00	.00	.00	0	1-02	1-20	144	.03	.02	.01	5
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1-01	9-10	49	.00	.00	.00	0	1-02	9-10	194	.03	.02	.01	24
1-01	9-20	50	.00	.00	.00	0	1-02	9-20	195	.03	.02	.01	24
1-01	9-30	51	.00	.00	.00	0	1-02	9-30	196	.03	.02	.01	24
1-01	9-40	52	.00	.00	.00	0	1-02	9-40	197	.03	.02	.01	24
1-01	9-50	53	.00	.00	.00	0	1-02	9-50	198	.03	.02	.01	24
1-01	10-00	54	.00	.00	.00	0	1-02	10-00	199	.03	.02	.01	24

PC	HR-MN	PERIOD	RAIN	EQCS	LOSS	COMP	0-DA	HR-MN	PERIOD	RAIN	EQCS	LOSS	COMP
1-01	1-10	55	.00	.00	.00	0	1-02	1-10	200	.03	.02	.01	24

1.01	9.10	55	.01	.00	.01	.00	.01	.02	9.10	199	.13	.12	.01	127.
1.01	9.20	56	.01	.00	.01	.00	.01	.02	9.20	200	.13	.12	.01	127.
1.01	9.30	57	.01	.00	.01	.00	.01	.02	9.30	201	.13	.12	.01	127.
1.01	9.40	58	.01	.00	.01	.00	.01	.02	9.40	202	.13	.12	.01	128.
1.01	9.50	59	.01	.00	.01	.00	.01	.02	9.50	203	.13	.12	.01	128.
1.01	10.00	60	.01	.00	.01	.00	.01	.02	10.00	204	.13	.12	.01	129.
1.01	10.10	61	.01	.00	.01	.00	.01	.02	10.10	205	.13	.12	.01	129.
1.01	10.20	62	.01	.00	.01	.00	.01	.02	10.20	206	.13	.12	.01	129.
1.01	10.30	63	.01	.00	.01	.00	.01	.02	10.30	207	.13	.12	.01	130.
1.01	10.40	64	.01	.00	.01	.00	.01	.02	10.40	208	.13	.12	.01	130.
1.01	10.50	65	.01	.00	.01	.00	.01	.02	10.50	209	.13	.12	.01	131.
1.01	11.00	66	.01	.00	.01	.00	.01	.02	11.00	210	.13	.12	.01	131.
1.01	11.10	67	.01	.00	.01	.00	.01	.02	11.10	211	.13	.12	.01	131.
1.01	11.20	68	.01	.00	.01	.00	.01	.02	11.20	212	.13	.12	.01	131.
1.01	11.30	69	.01	.00	.01	.00	.01	.02	11.30	213	.13	.12	.01	132.
1.01	11.40	70	.01	.00	.01	.00	.01	.02	11.40	214	.13	.12	.01	132.
1.01	11.50	71	.01	.00	.01	.00	.01	.02	11.50	215	.13	.12	.01	132.
1.01	12.00	72	.01	.00	.01	.00	.01	.02	12.00	216	.13	.12	.01	133.
1.01	12.10	73	.01	.00	.01	.00	.01	.02	12.10	217	.13	.12	.01	133.
1.01	12.20	74	.01	.00	.01	.00	.01	.02	12.20	218	.13	.12	.01	141.
1.01	12.30	75	.01	.00	.01	.00	.01	.02	12.30	219	.13	.12	.01	170.
1.01	12.40	76	.01	.00	.01	.00	.01	.02	12.40	220	.13	.12	.01	222.
1.01	12.50	77	.01	.00	.01	.00	.01	.02	12.50	221	.13	.12	.01	280.
1.01	13.00	78	.01	.00	.01	.00	.01	.02	13.00	222	.13	.12	.01	350.
1.01	13.10	79	.01	.00	.01	.00	.01	.02	13.10	223	.13	.12	.01	360.
1.01	13.20	80	.01	.00	.01	.00	.01	.02	13.20	224	.13	.12	.01	361.
1.01	13.30	81	.01	.00	.01	.00	.01	.02	13.30	225	.13	.12	.01	410.
1.01	13.40	82	.01	.00	.01	.00	.01	.02	13.40	226	.13	.12	.01	442.
1.01	13.50	83	.01	.00	.01	.00	.01	.02	13.50	227	.13	.12	.01	468.
1.01	14.00	84	.01	.00	.01	.00	.01	.02	14.00	228	.13	.12	.01	486.
1.01	14.10	85	.01	.00	.01	.00	.01	.02	14.10	229	.13	.12	.01	500.
1.01	14.20	86	.01	.00	.01	.00	.01	.02	14.20	230	.13	.12	.01	513.
1.01	14.30	87	.01	.00	.01	.00	.01	.02	14.30	231	.13	.12	.01	533.
1.01	14.40	88	.01	.00	.01	.00	.01	.02	14.40	232	.13	.12	.01	561.
1.01	14.50	89	.01	.00	.01	.00	.01	.02	14.50	233	.13	.12	.01	590.
1.01	15.00	90	.01	.00	.01	.00	.01	.02	15.00	234	.13	.12	.01	616.
1.01	15.10	91	.01	.00	.01	.00	.01	.02	15.10	235	.13	.12	.01	632.
1.01	15.20	92	.01	.00	.01	.00	.01	.02	15.20	236	.13	.12	.01	641.
1.01	15.30	93	.01	.00	.01	.00	.01	.02	15.30	237	.13	.12	.01	653.
1.01	15.40	94	.01	.00	.01	.00	.01	.02	15.40	238	.13	.12	.01	716.
1.01	15.50	95	.01	.00	.01	.00	.01	.02	15.50	239	.13	.12	.01	939.
1.01	16.00	96	.01	.00	.01	.00	.01	.02	16.00	240	.13	.12	.01	1320.
1.01	16.10	97	.01	.00	.01	.00	.01	.02	16.10	241	.13	.12	.01	1690.
1.01	16.20	98	.01	.00	.01	.00	.01	.02	16.20	242	.13	.12	.01	1783.
1.01	16.30	99	.01	.00	.01	.00	.01	.02	16.30	243	.13	.12	.01	1631.
1.01	16.40	100	.01	.00	.01	.00	.01	.02	16.40	244	.13	.12	.01	1361.
1.01	16.50	101	.01	.00	.01	.00	.01	.02	16.50	245	.13	.12	.01	1108.
1.01	17.00	102	.01	.00	.01	.00	.01	.02	17.00	246	.13	.12	.01	944.
1.01	17.10	103	.01	.00	.01	.00	.01	.02	17.10	247	.13	.12	.01	835.
1.01	17.20	104	.01	.00	.01	.00	.01	.02	17.20	248	.13	.12	.01	759.
1.01	17.30	105	.01	.00	.01	.00	.01	.02	17.30	249	.13	.12	.01	659.
1.01	17.40	106	.01	.00	.01	.00	.01	.02	17.40	250	.13	.12	.01	643.
1.01	17.50	107	.01	.00	.01	.00	.01	.02	17.50	251	.13	.12	.01	599.
1.01	18.00	108	.01	.00	.01	.00	.01	.02	18.00	252	.13	.12	.01	503.
1.01	18.10	109	.01	.00	.01	.00	.01	.02	18.10	253	.13	.12	.01	539.
1.01	18.20	110	.01	.00	.01	.00	.01	.02	18.20	254	.13	.12	.01	510.
1.01	18.30	111	.01	.00	.01	.00	.01	.02	18.30	255	.13	.12	.01	456.

TIME	15.37	15.40	15.43	15.46	15.49	15.52	15.55	15.58	16.01	16.04	16.07	16.10	16.13	16.16	16.19	16.22	16.25	16.28	16.31	16.34	16.37	16.40	16.43	16.46	16.49	16.52	16.55	16.58	17.01	17.04	17.07	17.10	17.13	17.16	17.19	17.22	17.25	17.28	17.31	17.34	17.37	17.40	17.43	17.46	17.49	17.52	17.55	17.58	18.01	18.04	18.07	18.10	18.13	18.16	18.19	18.22	18.25	18.28	18.31	18.34	18.37	18.40	18.43	18.46	18.49	18.52	18.55	18.58	19.01	19.04	19.07	19.10	19.13	19.16	19.19	19.22	19.25	19.28	19.31	19.34	19.37	19.40	19.43	19.46	19.49	19.52	19.55	19.58	20.01	20.04	20.07	20.10	20.13	20.16	20.19	20.22	20.25	20.28	20.31	20.34	20.37	20.40	20.43	20.46	20.49	20.52	20.55	20.58	21.01	21.04	21.07	21.10	21.13	21.16	21.19	21.22	21.25	21.28	21.31	21.34	21.37	21.40	21.43	21.46	21.49	21.52	21.55	21.58	22.01	22.04	22.07	22.10	22.13	22.16	22.19	22.22	22.25	22.28	22.31	22.34	22.37	22.40	22.43	22.46	22.49	22.52	22.55	22.58	23.01	23.04	23.07	23.10	23.13	23.16	23.19	23.22	23.25	23.28	23.31	23.34	23.37	23.40	23.43	23.46	23.49	23.52	23.55	23.58	24.01	24.04	24.07	24.10	24.13	24.16	24.19	24.22	24.25	24.28	24.31	24.34	24.37	24.40	24.43	24.46	24.49	24.52	24.55	24.58	25.01	25.04	25.07	25.10	25.13	25.16	25.19	25.22	25.25	25.28	25.31	25.34	25.37	25.40	25.43	25.46	25.49	25.52	25.55	25.58	26.01	26.04	26.07	26.10	26.13	26.16	26.19	26.22	26.25	26.28	26.31	26.34	26.37	26.40	26.43	26.46	26.49	26.52	26.55	26.58	27.01	27.04	27.07	27.10	27.13	27.16	27.19	27.22	27.25	27.28	27.31	27.34	27.37	27.40	27.43	27.46	27.49	27.52	27.55	27.58	28.01	28.04	28.07	28.10	28.13	28.16	28.19	28.22	28.25	28.28	28.31	28.34	28.37	28.40	28.43	28.46	28.49	28.52	28.55	28.58	29.01	29.04	29.07	29.10	29.13	29.16	29.19	29.22	29.25	29.28	29.31	29.34	29.37	29.40	29.43	29.46	29.49	29.52	29.55	29.58	30.01	30.04	30.07	30.10	30.13	30.16	30.19	30.22	30.25	30.28	30.31	30.34	30.37	30.40	30.43	30.46	30.49	30.52	30.55	30.58	31.01	31.04	31.07	31.10	31.13	31.16	31.19	31.22	31.25	31.28	31.31	31.34	31.37	31.40	31.43	31.46	31.49	31.52	31.55	31.58	32.01	32.04	32.07	32.10	32.13	32.16	32.19	32.22	32.25	32.28	32.31	32.34	32.37	32.40	32.43	32.46	32.49	32.52	32.55	32.58	33.01	33.04	33.07	33.10	33.13	33.16	33.19	33.22	33.25	33.28	33.31	33.34	33.37	33.40	33.43	33.46	33.49	33.52	33.55	33.58	34.01	34.04	34.07	34.10	34.13	34.16	34.19	34.22	34.25	34.28	34.31	34.34	34.37	34.40	34.43	34.46	34.49	34.52	34.55	34.58	35.01	35.04	35.07	35.10	35.13	35.16	35.19	35.22	35.25	35.28	35.31	35.34	35.37	35.40	35.43	35.46	35.49	35.52	35.55	35.58	36.01	36.04	36.07	36.10	36.13	36.16	36.19	36.22	36.25	36.28	36.31	36.34	36.37	36.40	36.43	36.46	36.49	36.52	36.55	36.58	37.01	37.04	37.07	37.10	37.13	37.16	37.19	37.22	37.25	37.28	37.31	37.34	37.37	37.40	37.43	37.46	37.49	37.52	37.55	37.58	38.01	38.04	38.07	38.10	38.13	38.16	38.19	38.22	38.25	38.28	38.31	38.34	38.37	38.40	38.43	38.46	38.49	38.52	38.55	38.58	39.01	39.04	39.07	39.10	39.13	39.16	39.19	39.22	39.25	39.28	39.31	39.34	39.37	39.40	39.43	39.46	39.49	39.52	39.55	39.58	40.01	40.04	40.07	40.10	40.13	40.16	40.19	40.22	40.25	40.28	40.31	40.34	40.37	40.40	40.43	40.46	40.49	40.52	40.55	40.58	41.01	41.04	41.07	41.10	41.13	41.16	41.19	41.22	41.25	41.28	41.31	41.34	41.37	41.40	41.43	41.46	41.49	41.52	41.55	41.58	42.01	42.04	42.07	42.10	42.13	42.16	42.19	42.22	42.25	42.28	42.31	42.34	42.37	42.40	42.43	42.46	42.49	42.52	42.55	42.58	43.01	43.04	43.07	43.10	43.13	43.16	43.19	43.22	43.25	43.28	43.31	43.34	43.37	43.40	43.43	43.46	43.49	43.52	43.55	43.58	44.01	44.04	44.07	44.10	44.13	44.16	44.19	44.22	44.25	44.28	44.31	44.34	44.37	44.40	44.43	44.46	44.49	44.52	44.55	44.58	45.01	45.04	45.07	45.10	45.13	45.16	45.19	45.22	45.25	45.28	45.31	45.34	45.37	45.40	45.43	45.46	45.49	45.52	45.55	45.58	46.01	46.04	46.07	46.10	46.13	46.16	46.19	46.22	46.25	46.28	46.31	46.34	46.37	46.40	46.43	46.46	46.49	46.52	46.55	46.58	47.01	47.04	47.07	47.10	47.13	47.16	47.19	47.22	47.25	47.28	47.31	47.34	47.37	47.40	47.43	47.46	47.49	47.52	47.55	47.58	48.01	48.04	48.07	48.10	48.13	48.16	48.19	48.22	48.25	48.28	48.31	48.34	48.37	48.40	48.43	48.46	48.49	48.52	48.55	48.58	49.01	49.04	49.07	49.10	49.13	49.16	49.19	49.22	49.25	49.28	49.31	49.34	49.37	49.40	49.43	49.46	49.49	49.52	49.55	49.58	50.01	50.04	50.07	50.10	50.13	50.16	50.19	50.22	50.25	50.28	50.31	50.34	50.37	50.40	50.43	50.46	50.49	50.52	50.55	50.58	51.01	51.04	51.07	51.10	51.13	51.16	51.19	51.22	51.25	51.28	51.31	51.34	51.37	51.40	51.43	51.46	51.49	51.52	51.55	51.58	52.01	52.04	52.07	52.10	52.13	52.16	52.19	52.22	52.25	52.28	52.31	52.34	52.37	52.40	52.43	52.46	52.49	52.52	52.55	52.58	53.01	53.04	53.07	53.10	53.13	53.16	53.19	53.22	53.25	53.28	53.31	53.34	53.37	53.40	53.43	53.46	53.49	53.52	53.55	53.58	54.01	54.04	54.07	54.10	54.13	54.16	54.19	54.22	54.25	54.28	54.31	54.34	54.37	54.40	54.43	54.46	54.49	54.52	54.55	54.58	55.01	55.04	55.07	55.10	55.13	55.16	55.19	55.22	55.25	55.28	55.31	55.34	55.37	55.40	55.43	55.46	55.49	55.52	55.55	55.58	56.01	56.04	56.07	56.10	56.13	56.16	56.19	56.22	56.25	56.28	56.31	56.34	56.37	56.40	56.43	56.46	56.49	56.52	56.55	56.58	57.01	57.04	57.07	57.10	57.13	57.16	57.19	57.22	57.25	57.28	57.31	57.34	57.37	57.40	57.43	57.46	57.49	57.52	57.55	57.58	58.01	58.04	58.07	58.10	58.13	58.16	58.19	58.22	58.25	58.28	58.31	58.34	58.37	58.40	58.43	58.46	58.49	58.52	58.55	58.58	59.01	59.04	59.07	59.10	59.13	59.16	59.19	59.22	59.25	59.28	59.31	59.34	59.37	59.40	59.43	59.46	59.49	59.52	59.55	59.58	60.01	60.04	60.07	60.10	60.13	60.16	60.19	60.22	60.25	60.28	60.31	60.34	60.37	60.40	60.43	60.46	60.49	60.52	60.55	60.58	61.01	61.04	61.07	61.10	61.13	61.16	61.19	61.22	61.25	61.28	61.31	61.34	61.37	61.40	61.43	61.46	61.49	61.52	61.55	61.58	62.01	62.04	62.07	62.10	62.13	62.16	62.19	62.22	62.25	62.28	62.31	62.34	62.37	62.40	62.43	62.46	62.49	62.52	62.55	62.58	63.01	63.04	63.07	63.10	63.13	63.16	63.19	63.22	63.25	63.28	63.31	63.34	63.37	63.40	63.43	63.46	63.49	63.52	63.55	63.58	64.01	64.04	64.07	64.10	64.13	64.16	64.19	64.22	64.25	64.28	64.31	64.34	64.37	64.40	64.43	64.46	64.49	64.52	64.55	64.58	65.01	65.04	65.07	65.10	65.13	65.16	65.19	65.22	65.25	65.28	65.31	65.34	65.37	65.40	65.43	65.46	65.49	65.52	65.55	65.58	66.01	66.04	66.07	66.10	66.13	66.16	66.19	66.22	66.25	66.28	66.31	66.34	66.37	66.40	66.43	66.46	66.49	66.52	66.55	66.58	67.01	67.04	67.07	67.10	67.13	67.16	67.19	67.22	67.25	67.28	67.31	67.34	67.37	67.40	67.43	67.46	67.49	67.52	67.55	67.58	68.01	68.04	68.07	68.10	68.13	68.16	68.19	68.22	68.25	68.28	68.31	68.34	68.37	68.40	68.43	68.46	68.49	68.52	68.55	68.58	69.01	69.04	69.07	69.10	69.13	69.16	69.19	69.22	69.25	69.28	69.31	69.34	69.37	69.40	69.43	69.46	69.49	69.52	69.55	69.58	70.01	70.04	70.07	70.10	70.13	70.16	70.19	70.22	70.25	70.28	70.31	70.34	70.37	70.40	70.43	70.46	70.49	70.52	70.55	70.58	71.01	71.04	71.07	71.10	71.13	71.16	71.19	71.22	71.25	71.28	71.31	71.34	71.37	71.40	71.43	71.46	71.49	71.52	71.55	71.58	72.01	72.04	72.07	72.10	72.13	72.16	72.19	72.22	72.25	72.28	72.31	72.34	72.37	72.40	72.43	72.46	72.49	72.52	72.55	72.58	73.01	73.04	73.07	73.10	73.13	73.16	73.19	73.22	73.25	73.28	73.31	73.34	73.37	73.40	73.43	73.46	73.49	73.52	73.55	73.58	74.01	74.04	74.07	74.10	74.13	74.16	74.19	74.22	74.25	74.28	74.31	74.34	74.37	74.40	74.43	74.46	74.49	74.52	74.55	74.58	75.01	75.04	75.07	75.10	75.13	75.16	75.19	75.22	75.25	75.28	75.31	75.34	75.37	75.40	75.43	75.46	75.49	75.52	75.55	75.58	76.01	76.04	76.07	76.10	76.13	76.16	76.19	76.22	76.25	76.28	76.31	76.34	76.37	76.40	76.43	76.46	76.49
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THOUS CU M 110. 142. 144. 146.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME
535. 216. 29. 36. 10315.
CFS 15. 6. 2. 1. 262.
CMS
INCHES 7.17 9.25 9.52 9.52
162.07 234.85 241.80 241.80
PM 107. 137. 142. 142.
AC-FT 132. 175. 175. 175.
THOUS CU M

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 3

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME
891. 360. 116. 6. 17192.
CFS 25. 15. 3. 2. 487.
CMS
INCHES 11.95 15.41 15.87 15.87
431.45 591.42 602.99 602.99
MK 178. 230. 237. 237.
AC-FT 220. 224. 297. 292.
THOUS CU M

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 4

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME
1783. 719. 232. 110. 34365.
CFS 56. 26. 7. 4. 974.
CMS
INCHES 23.89 30.82 31.73 31.73
646.89 742.25 805.99 805.99
MK 757. 460. 474. 474.
AC-FT 440. 567. 584. 584.
THOUS CU M

HYDROGRAPH ROUTING

ROUTING THROUGH UPSTREAM DAM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPAT	INAME	ISTAGE	IAUTO
2	1	2	2	0	0	1	0	0
ROUTING DATA								
GLOSS	CLOSS	AVG	IRMS	ISAPE	IOPT	IPMP	LSTR	
.3	.000	.00	1	1	0	0	0	
NSTPS NSTOL LAG ARSKN X TSK STORA ISPPAT								
1	0	0	0	0	0	0	0	-1

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SUB-AREA RUNOFF COMPUTATION

PERTLE SPRINGS DAM (48 HR. PROBABLE MAXIMUM RUNOFF)

ISTAG 3 ICOMP 0 IECON 0 ITRAP 0 JPLT 0 JPRY 3 ISAME 1 ISAGE 0 IAUQ 0
 INTD 1 IUNG 2 TAREA 3 SNAP 43 TNSPC 0 RATIO 0 ISNO 0 ISAME 0 LOCAL 0

HYDROGRAPH DATA

SPFC PHS R6 R12 R24 R48 R72 R96
 .00 24.70 101.00 120.00 130.00 140.00 .00

LOSS DATA

LROPT STKOP OLTER RTIOL ERRAIN STRCS RTIOW STIOL CMSTL ALSMR RTIMP
 0 .00 .00 1.00 .00 .00 1.00 -1.00 -00.00 .00 .00

CURVE NO = -00.00 -EINNESS = -1.00 EFFECT CM = 80.00

UNIT HYDROGRAPH DATA

TC = .00 LAG = .63

RECESSION DATA

SIRIR = .00 QECEN = .00 RIQR = 1.00

UNIT HYDROGRAPH 21 END OF PERIOD ORIGINATES, TC = .00 HOURS, LAG = .63 VOL = 1.00
 35. 112. 224. 256. 272. 288. 304. 320. 336. 352. 368. 384. 400. 416. 432. 448. 464. 480. 496. 512. 528. 544. 560. 576. 592. 608. 624. 640. 656. 672. 688. 704. 720. 736. 752. 768. 784. 800. 816. 832. 848. 864. 880. 896. 912. 928. 944. 960. 976. 992. 1008. 1024. 1040. 1056. 1072. 1088. 1104. 1120. 1136. 1152. 1168. 1184. 1200. 1216. 1232. 1248. 1264. 1280. 1296. 1312. 1328. 1344. 1360. 1376. 1392. 1408. 1424. 1440. 1456. 1472. 1488. 1504. 1520. 1536. 1552. 1568. 1584. 1600. 1616. 1632. 1648. 1664. 1680. 1696. 1712. 1728. 1744. 1760. 1776. 1792. 1808. 1824. 1840. 1856. 1872. 1888. 1904. 1920. 1936. 1952. 1968. 1984. 2000. 2016. 2032. 2048. 2064. 2080. 2096. 2112. 2128. 2144. 2160. 2176. 2192. 2208. 2224. 2240. 2256. 2272. 2288. 2304. 2320. 2336. 2352. 2368. 2384. 2400. 2416. 2432. 2448. 2464. 2480. 2496. 2512. 2528. 2544. 2560. 2576. 2592. 2608. 2624. 2640. 2656. 2672. 2688. 2704. 2720. 2736. 2752. 2768. 2784. 2800. 2816. 2832. 2848. 2864. 2880. 2896. 2912. 2928. 2944. 2960. 2976. 2992. 3008. 3024. 3040. 3056. 3072. 3088. 3104. 3120. 3136. 3152. 3168. 3184. 3200. 3216. 3232. 3248. 3264. 3280. 3296. 3312. 3328. 3344. 3360. 3376. 3392. 3408. 3424. 3440. 3456. 3472. 3488. 3504. 3520. 3536. 3552. 3568. 3584. 3600. 3616. 3632. 3648. 3664. 3680. 3696. 3712. 3728. 3744. 3760. 3776. 3792. 3808. 3824. 3840. 3856. 3872. 3888. 3904. 3920. 3936. 3952. 3968. 3984. 4000. 4016. 4032. 4048. 4064. 4080. 4096. 4112. 4128. 4144. 4160. 4176. 4192. 4208. 4224. 4240. 4256. 4272. 4288. 4304. 4320. 4336. 4352. 4368. 4384. 4400. 4416. 4432. 4448. 4464. 4480. 4496. 4512. 4528. 4544. 4560. 4576. 4592. 4608. 4624. 4640. 4656. 4672. 4688. 4704. 4720. 4736. 4752. 4768. 4784. 4800. 4816. 4832. 4848. 4864. 4880. 4896. 4912. 4928. 4944. 4960. 4976. 4992. 5008. 5024. 5040. 5056. 5072. 5088. 5104. 5120. 5136. 5152. 5168. 5184. 5200. 5216. 5232. 5248. 5264. 5280. 5296. 5312. 5328. 5344. 5360. 5376. 5392. 5408. 5424. 5440. 5456. 5472. 5488. 5504. 5520. 5536. 5552. 5568. 5584. 5600. 5616. 5632. 5648. 5664. 5680. 5696. 5712. 5728. 5744. 5760. 5776. 5792. 5808. 5824. 5840. 5856. 5872. 5888. 5904. 5920. 5936. 5952. 5968. 5984. 6000. 6016. 6032. 6048. 6064. 6080. 6096. 6112. 6128. 6144. 6160. 6176. 6192. 6208. 6224. 6240. 6256. 6272. 6288. 6304. 6320. 6336. 6352. 6368. 6384. 6400. 6416. 6432. 6448. 6464. 6480. 6496. 6512. 6528. 6544. 6560. 6576. 6592. 6608. 6624. 6640. 6656. 6672. 6688. 6704. 6720. 6736. 6752. 6768. 6784. 6800. 6816. 6832. 6848. 6864. 6880. 6896. 6912. 6928. 6944. 6960. 6976. 6992. 7008. 7024. 7040. 7056. 7072. 7088. 7104. 7120. 7136. 7152. 7168. 7184. 7200. 7216. 7232. 7248. 7264. 7280. 7296. 7312. 7328. 7344. 7360. 7376. 7392. 7408. 7424. 7440. 7456. 7472. 7488. 7504. 7520. 7536. 7552. 7568. 7584. 7600. 7616. 7632. 7648. 7664. 7680. 7696. 7712. 7728. 7744. 7760. 7776. 7792. 7808. 7824. 7840. 7856. 7872. 7888. 7904. 7920. 7936. 7952. 7968. 7984. 8000. 8016. 8032. 8048. 8064. 8080. 8096. 8112. 8128. 8144. 8160. 8176. 8192. 8208. 8224. 8240. 8256. 8272. 8288. 8304. 8320. 8336. 8352. 8368. 8384. 8400. 8416. 8432. 8448. 8464. 8480. 8496. 8512. 8528. 8544. 8560. 8576. 8592. 8608. 8624. 8640. 8656. 8672. 8688. 8704. 8720. 8736. 8752. 8768. 8784. 8800. 8816. 8832. 8848. 8864. 8880. 8896. 8912. 8928. 8944. 8960. 8976. 8992. 9008. 9024. 9040. 9056. 9072. 9088. 9104. 9120. 9136. 9152. 9168. 9184. 9200. 9216. 9232. 9248. 9264. 9280. 9296. 9312. 9328. 9344. 9360. 9376. 9392. 9408. 9424. 9440. 9456. 9472. 9488. 9504. 9520. 9536. 9552. 9568. 9584. 9600. 9616. 9632. 9648. 9664. 9680. 9696. 9712. 9728. 9744. 9760. 9776. 9792. 9808. 9824. 9840. 9856. 9872. 9888. 9904. 9920. 9936. 9952. 9968. 9984. 10000.

END-OF-PERIOD FLOW

MO-DA	HR-MN	PERIOD	RAIN	EXCS	LOSS	COMP	MO-DA	HR-MN	PERIOD	RAIN	EXCS	LOSS	COMP
1-01	1-10	1	.00	.00	.00	.00	1-02	1-10	145	.03	.02	.01	4.
1-01	1-20	2	.00	.00	.00	.00	1-02	1-20	146	.03	.02	.01	6.
1-01	1-30	3	.00	.00	.00	.00	1-02	1-30	147	.03	.02	.01	10.
1-01	1-40	4	.00	.00	.00	.00	1-02	1-40	148	.03	.02	.01	15.
1-01	1-50	5	.00	.00	.00	.00	1-02	1-50	149	.03	.02	.01	19.
1-01	1-00	6	.00	.00	.00	.00	1-02	1-00	150	.03	.02	.01	23.
1-01	1-10	7	.00	.00	.00	.00	1-02	1-10	151	.03	.02	.01	26.
1-01	1-20	8	.00	.00	.00	.00	1-02	1-20	152	.03	.02	.01	28.
1-01	1-30	9	.00	.00	.00	.00	1-02	1-30	153	.03	.02	.01	29.
1-01	1-40	10	.00	.00	.00	.00	1-02	1-40	154	.03	.02	.01	30.
1-01	1-50	11	.00	.00	.00	.00	1-02	1-50	155	.03	.02	.01	31.
1-01	2-00	12	.00	.00	.00	.00	1-02	2-00	156	.03	.02	.01	32.
1-01	2-10	13	.00	.00	.00	.00	1-02	2-10	157	.03	.02	.01	32.
1-01	2-20	14	.00	.00	.00	.00	1-02	2-20	158	.03	.02	.01	32.
1-01	2-30	15	.00	.00	.00	.00	1-02	2-30	159	.03	.02	.01	33.

BLACK & VEATCH
2000 MIDGRAPH PACKAGE - REC-1

1.01	12.00	72	61	00	01	00	1.02	12.00	216	13	12	01
1.01	12.10	73	63	03	03	00	1.02	12.10	217	42	39	02
1.01	12.20	74	65	05	05	00	1.02	12.20	218	42	39	02
1.01	12.30	75	67	07	07	00	1.02	12.30	219	42	40	02
1.01	12.40	76	69	09	09	00	1.02	12.40	220	42	41	02
1.01	12.50	77	71	11	11	00	1.02	12.50	221	42	42	02
1.01	13.00	78	73	13	13	00	1.02	13.00	222	42	40	02
1.01	13.10	79	75	15	15	00	1.02	13.10	223	50	42	02
1.01	13.20	80	77	17	17	00	1.02	13.20	224	50	42	02
1.01	13.30	81	79	19	19	00	1.02	13.30	225	50	48	02
1.01	13.40	82	81	21	21	00	1.02	13.40	226	50	48	02
1.01	13.50	83	83	23	23	00	1.02	13.50	227	50	49	01
1.01	14.00	84	85	25	25	00	1.02	14.00	228	50	49	01
1.01	14.10	85	87	27	27	00	1.02	14.10	229	62	61	02
1.01	14.20	86	89	29	29	00	1.02	14.20	230	62	61	01
1.01	14.30	87	91	31	31	00	1.02	14.30	231	62	61	01
1.01	14.40	88	93	33	33	00	1.02	14.40	232	62	61	01
1.01	14.50	89	95	35	35	00	1.02	14.50	233	62	61	01
1.01	15.00	90	97	37	37	00	1.02	15.00	234	62	61	01
1.01	15.10	91	99	39	39	00	1.02	15.10	235	57	54	01
1.01	15.20	92	101	41	41	00	1.02	15.20	236	93	93	01
1.01	15.30	93	103	43	43	00	1.02	15.30	237	171	168	02
1.01	15.40	94	105	45	45	00	1.02	15.40	238	427	422	04
1.01	15.50	95	107	47	47	00	1.02	15.50	239	123	122	03
1.01	16.00	96	109	49	49	00	1.02	16.00	240	76	75	01
1.01	16.10	97	111	51	51	00	1.02	16.10	241	50	58	00
1.01	16.20	98	113	53	53	00	1.02	16.20	242	50	58	00
1.01	16.30	99	115	55	55	00	1.02	16.30	243	58	58	00
1.01	16.40	100	117	57	57	00	1.02	16.40	244	58	58	00
1.01	16.50	101	119	59	59	00	1.02	16.50	245	58	58	00
1.01	17.00	102	121	61	61	00	1.02	17.00	246	56	58	00
1.01	17.10	103	123	63	63	00	1.02	17.10	247	46	45	00
1.01	17.20	104	125	65	65	00	1.02	17.20	248	40	45	00
1.01	17.30	105	127	67	67	00	1.02	17.30	249	40	45	00
1.01	17.40	106	129	69	69	00	1.02	17.40	250	40	45	00
1.01	17.50	107	131	71	71	00	1.02	17.50	251	40	45	00
1.01	18.00	108	133	73	73	00	1.02	18.00	252	40	46	00
1.01	18.10	109	135	75	75	00	1.02	18.10	253	04	04	00
1.01	18.20	110	137	77	77	00	1.02	18.20	254	04	04	00
1.01	18.30	111	139	79	79	00	1.02	18.30	255	04	04	00
1.01	18.40	112	141	81	81	00	1.02	18.40	256	04	04	00
1.01	18.50	113	143	83	83	00	1.02	18.50	257	04	04	00
1.01	19.00	114	145	85	85	00	1.02	19.00	258	04	04	00
1.01	19.10	115	147	87	87	00	1.02	19.10	259	04	04	00
1.01	19.20	116	149	89	89	00	1.02	19.20	260	04	04	00
1.01	19.30	117	151	91	91	00	1.02	19.30	261	04	04	00
1.01	19.40	118	153	93	93	00	1.02	19.40	262	04	04	00
1.01	19.50	119	155	95	95	00	1.02	19.50	263	04	04	00
1.01	20.00	120	157	97	97	00	1.02	20.00	264	04	04	00
1.01	20.10	121	159	99	99	00	1.02	20.10	265	04	04	00
1.01	20.20	122	161	101	101	00	1.02	20.20	266	04	04	00
1.01	20.30	123	163	103	103	00	1.02	20.30	267	04	04	00
1.01	20.40	124	165	105	105	00	1.02	20.40	268	04	04	00
1.01	20.50	125	167	107	107	00	1.02	20.50	269	04	04	00
1.01	21.00	126	169	109	109	00	1.02	21.00	270	04	04	00
1.01	21.10	127	171	111	111	00	1.02	21.10	271	04	04	00

0 L A C K S V E A T C H
=====

2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.	63.	64.	65.	66.	67.	68.	69.	70.	71.	72.	73.	74.	75.	76.	77.	78.	79.	80.	81.	82.	83.	84.	85.	86.	87.	88.	89.	90.	91.	92.	93.	94.	95.	96.	97.	98.	99.	100.
2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.	63.	64.	65.	66.	67.	68.	69.	70.	71.	72.	73.	74.	75.	76.	77.	78.	79.	80.	81.	82.	83.	84.	85.	86.	87.	88.	89.	90.	91.	92.	93.	94.	95.	96.	97.	98.	99.	100.
2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.	63.	64.	65.	66.	67.	68.	69.	70.	71.	72.	73.	74.	75.	76.	77.	78.	79.	80.	81.	82.	83.	84.	85.	86.	87.	88.	89.	90.	91.	92.	93.	94.	95.	96.	97.	98.	99.	100.

PEAK	6-HOUR	44-HOUR	72-HOUR	TOTAL VOLUME
4325.	1515.	566.	302.	6451.
CFS	122.	51.	17.	242.
INCHES	23.78	30.73	31.45	31.45
PM	602.12	780.45	803.78	803.78
AC-FT	900.	1103.	1199.	1199.
THOUS CU M	1110.	1434.	1477.	1477.

HYDROGRAPH ROUTING

ROUTING THROUGH PERTLE SPRINGS LAKE

STAGE	774.00	775.00	776.00	777.00	778.00	779.00	780.00	781.00	782.00
FLOW	0.	33.30	191.00	348.00	532.00	715.00	915.00	1125.00	1341.00
SURFACE AREA	0.	16.	32.	38.	66.	78.	97.		

CAPACITY	0.	75.	218.	573.	1077.	1907.	2677.
ELEVATION	763.	774.	783.	792.	802.	813.	826.
	CRCL	SPWID	COUL	EXPL	ELEV	COUL	CAREA
	774.0	0.0	0.0	0.0	0.0	0.0	0.0
CREST LENGTH	11.	31.	144.	194.	349.	514.	559.
AT OR BELOW							
ELEVATION	776.0	776.5	777.0	777.6	777.8	778.0	779.5

STATION 5+ PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

DPM DATA									
TOPEL COUL EXPL DARVID									
777.6 0.0 0.0 0.0									
OUTFLOW									
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
1.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12.	0.	0.	0.	0.	0.	0.	0.	0.	0.
13.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50.	0.	0.	0.	0.	0.	0.	0.	0.	0.
51.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52.	0.	0.	0.	0.	0.	0.	0.	0.	0.
53.	0.	0.	0.	0.	0.	0.	0.	0.	0.
54.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61.	0.	0.	0.	0.	0.	0.	0.	0.	0.
62.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64.	0.	0.	0.	0.	0.	0.	0.	0.	0.
65.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68.	0.	0.	0.	0.	0.	0.	0.	0.	0.
69.	0.	0.	0.	0.	0.	0.	0.	0.	0.
70.	0.	0.	0.	0.	0.	0.	0.	0.	0.
71.	0.	0.	0.	0.	0.	0.	0.	0.	0.
72.	0.	0.	0.	0.	0.	0.	0.	0.	0.
73.	0.	0.	0.	0.	0.	0.	0.	0.	0.
74.	0.	0.	0.	0.	0.	0.	0.	0.	0.
75.	0.	0.	0.	0.	0.	0.	0.	0.	0.
76.	0.	0.	0.	0.	0.	0.	0.	0.	0.
77.	0.	0.	0.	0.	0.	0.	0.	0.	0.
78.	0.	0.	0.	0.	0.	0.	0.	0.	0.
79.	0.	0.	0.	0.	0.	0.	0.	0.	0.
80.	0.	0.	0.	0.	0.	0.	0.	0.	0.
81.	0.	0.	0.	0.	0.	0.	0.	0.	0.
82.	0.	0.	0.	0.	0.	0.	0.	0.	0.
83.	0.	0.	0.	0.	0.	0.	0.	0.	0.
84.	0.	0.	0.	0.	0.	0.	0.	0.	0.
85.	0.	0.	0.	0.	0.	0.	0.	0.	0.
86.	0.	0.	0.	0.	0.	0.	0.	0.	0.
87.	0.	0.	0.	0.	0.	0.	0.	0.	0.
88.	0.	0.	0.	0.	0.	0.	0.	0.	0.
89.	0.	0.	0.	0.	0.	0.	0.	0.	0.
90.	0.	0.	0.	0.	0.	0.	0.	0.	0.
91.	0.	0.	0.	0.	0.	0.	0.	0.	0.
92.	0.	0.	0.	0.	0.	0.	0.	0.	0.
93.	0.	0.	0.	0.	0.	0.	0.	0.	0.
94.	0.	0.	0.	0.	0.	0.	0.	0.	0.
95.	0.	0.	0.	0.	0.	0.	0.	0.	0.
96.	0.	0.	0.	0.	0.	0.	0.	0.	0.
97.	0.	0.	0.	0.	0.	0.	0.	0.	0.
98.	0.	0.	0.	0.	0.	0.	0.	0.	0.
99.	0.	0.	0.	0.	0.	0.	0.	0.	0.
100.	0.	0.	0.	0.	0.	0.	0.	0.	0.
101.	0.	0.	0.	0.	0.	0.	0.	0.	0.
102.	0.	0.	0.	0.	0.	0.	0.	0.	0.
103.	0.	0.	0.	0.	0.	0.	0.	0.	0.
104.	0.	0.	0.	0.	0.	0.	0.	0.	0.
105.	0.	0.	0.	0.	0.	0.	0.	0.	0.
106.	0.	0.	0.	0.	0.	0.	0.	0.	0.
107.	0.	0.	0.	0.	0.	0.	0.	0.	0.
108.	0.	0.	0.	0.	0.	0.	0.	0.	0.
109.	0.	0.	0.	0.	0.	0.	0.	0.	0.
110.	0.	0.	0.	0.	0.	0.	0.	0.	0.
111.	0.	0.	0.	0.	0.	0.	0.	0.	0.
112.	0.	0.	0.	0.	0.	0.	0.	0.	0.
113.	0.	0.	0.	0.	0.	0.	0.	0.	0.
114.	0.	0.	0.	0.	0.	0.	0.	0.	0.
115.	0.	0.	0.	0.	0.	0.	0.	0.	0.
116.	0.	0.	0.	0.	0.	0.	0.	0.	0.
117.	0.	0.	0.	0.	0.	0.	0.	0.	0.
118.	0.	0.	0.	0.	0.	0.	0.	0.	0.
119.	0.	0.	0.	0.	0.	0.	0.	0.	0.
120.	0.	0.	0.	0.	0.	0.	0.	0.	0.
121.	0.	0.	0.	0.	0.	0.	0.	0.	0.
122.	0.	0.	0.	0.	0.	0.	0.	0.	0.
123.	0.	0.	0.	0.	0.	0.	0.	0.	0.
124.	0.	0.	0.	0.	0.	0.	0.	0.	0.
125.	0.	0.	0.	0.	0.	0.	0.	0.	0.
126.	0.	0.	0.	0.	0.	0.	0.	0.	0.
127.	0.	0.	0.	0.	0.	0.	0.	0.	0.
128.	0.	0.	0.	0.	0.	0.	0.	0.	0.
129.	0.	0.	0.	0.	0.	0.	0.	0.	0.
130.	0.	0.	0.	0.	0.	0.	0.	0.	0.
131.	0.	0.	0.	0.	0.	0.	0.	0.	0.
132.	0.	0.	0.	0.	0.	0.	0.	0.	0.
133.	0.	0.	0.	0.	0.	0.	0.	0.	0.
134.	0.	0.	0.	0.	0.	0.	0.	0.	0.
135.	0.	0.	0.	0.	0.	0.	0.	0.	0.
136.	0.	0.	0.	0.	0.	0.	0.	0.	0.
137.	0.	0.	0.	0.	0.	0.	0.	0.	0.
138.	0.	0.	0.	0.	0.	0.	0.	0.	0.
139.	0.	0.	0.	0.	0.	0.	0.	0.	0.
140.	0.	0.	0.	0.	0.	0.	0.	0.	0.
141.	0.	0.	0.	0.	0.	0.	0.	0.	0.
142.	0.	0.	0.	0.	0.	0.	0.	0.	0.
143.	0.	0.	0.	0.	0.	0.	0.	0.	0.
144.	0.	0.	0.	0.	0.	0.	0.	0.	0.
145.	0.	0.	0.	0.	0.	0.	0.	0.	0.
146.	0.	0.	0.	0.	0.	0.	0.	0.	0.
147.	0.	0.	0.	0.	0.	0.	0.	0.	0.
148.	0.	0.	0.	0.	0.	0.	0.	0.	0.
149.	0.	0.	0.	0.	0.	0.	0.	0.	0.
150.	0.	0.	0.	0.	0.	0.	0.	0.	0.
151.	0.	0.	0.	0.	0.	0.	0.	0.	0.
152.	0.	0.	0.	0.	0.	0.	0.	0.	0.
153.	0.	0.	0.	0.	0.	0.	0.	0.	0.
154.	0.	0.	0.	0.	0.	0.	0.	0.	0.
155.	0.	0.	0.	0.	0.	0.	0.	0.	0.
156.	0.	0.	0.	0.	0.	0.	0.	0.	0.
157.	0.	0.	0.	0.	0.	0.	0.	0.	0.
158.	0.	0.	0.	0.	0.	0.	0.	0.	0.
159.	0.	0.	0.	0.	0.	0.	0.	0.	0.
160.	0.	0.	0.	0.	0.	0.	0.	0.	0.
161.	0.	0.	0.	0.	0.	0.	0.	0.	0.
162.	0.	0.	0.	0.	0.	0.	0.	0.	0.
163.	0.	0.	0.	0.	0.	0.	0.	0.	0.
164.	0.	0.	0.	0.	0.	0.	0.	0.	0.
165.	0.	0.	0.	0.	0.	0.	0.	0.	0.
166.	0.	0.	0.	0.	0.	0.	0.	0.	0.

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN (CUBIC FEET PER SECOND) (CUBIC METERS PER SECOND)
 AREA IN SQUARE FEET (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO	RATIOS APPLIED TO FLOWS			
					1	2	3	4
					.25	.30	.50	1.00
HYDROGRAPH AT	1	.20	1	440.	535.	951.	1753.	
	(	.73)	(	12.02)	15.74)	25.24)	52.46)	
ROUTED TO	2	.28	1	423.	506.	859.	1786.	
	(	.73)	(	11.97)	14.34)	24.33)	50.47)	
HYDROGRAPH AT	3	.43	1	634.	781.	1266.	2536.	
	(	1.11)	(	17.95)	21.54)	35.90)	71.80)	
2 COMBINED	4	.71	1	1046.	1254.	2106.	4325.	
	(	1.84)	(	29.03)	35.32)	59.83)	122.46)	
ROUTED TO	5	.71	1	982.	1111.	1942.	4209.	
	(	1.84)	(	24.98)	31.46)	56.46)	119.17)	

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1									
ELEVATION		INITIAL VALUE		SPILLWAY CREST		TOP OF DAM			
STORAGE		755.0		765.20		760.20			
OUTFLOW		0.		9.		9.			
				11.		11.			
RATIO OF PMF	MAXIMUM RESERVOIR ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS		
.25	750.29	.74	9.	423.	.50	40.33	34.83		
.50	759.29	.79	9.	508.	.52	40.33	33.83		
.75	769.38	.18	9.	859.	.52	40.33	32.33		
1.00	790.31	1.11	12.	1789.	1.98	40.17	17.67		

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1							
ELEVATION		INITIAL VALUE		SPILLWAY CREST		TOP OF DAM	
STORAGE		74.00		774.00		777.60	
OUTFLOW		75.		75.		145.	
		0.		3.		924.	
RATIO OF PMF	MAXIMUM RESERVOIR ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
	.25	777.50	.06	148.	482.	.00	40.50
	.50	777.77	.17	153.	1111.	.67	40.50
	.50	778.27	.67	166.	1994.	4.00	40.33
	1.00	779.05	1.45	189.	4209.	5.33	40.33

END

DATE
FILMED

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